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HYDROGENIC ACCUMULATION OF SILICA COMPOUNDS AND SESQUIOXIDES IN SOILS OF THE AMUR FORELAND

V. A. Kovda, B. A. Zimovets and A. G. Amchislavskaya,

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Many authors have recorded whitish "siliceous sprinklings" as well as finely divided manganese-iron concretions in the meadow and gley-meadow soils of the ancient alluvial plains of the Amur foreland. Manganese-iron concretions are found in varying quantities throughout the whole profile of hydromorphic soils, but their maximum accumulation is formed at a depth of 10 to 30 cm. (amounting up to 1 or 2 to 9% by weight). The whitish siliceous grains may be traced down to a depth of 70 or 100 to 180 cm. in the subhumic part of the soil profile. Sometimes opaline incrustations and scales are also found at this depth.

The presence of whitish grains has been explained by the processes of podzolization (3), of solodization (10, 11), or of hydrolysis of alumino-silicates *in situ* (13).

Observing the accumulation and diffusion of these new formations in the soils of the Amur foreland, during 1956 and 1957 we concluded that part of them originate in a process of hydrogenic accumulation of silica compounds and of sesquioxides from soil and ground water.

Surface, soil and ground water flow down from the foothills and mountain ranges bordering the alluvial plains and terraces, transporting dissolved products of soil formation and weathering, especially, compounds of silica, aluminum and iron. It was established from chemical analysis of soil and ground water from the foothills and plains of the Amur foreland (see Table 1), that in the fresh water from elevated plains and foothills, having a mineral content of 50 to 100 milligrams per liter and a pH of 5.5 to 6.5, the silica content amounts to 30 and sometimes 40 milligrams per liter. This constitutes 20 to 40% (sometimes even 50%) of the total ions, and 60 to 80% of the total alkalinity (HCO_3). In other words, according to their chemical composition, these waters are of the bicarbonate-silicate type.

The waters from lower-lying plains and terraces are of the silicate-bicarbonate type, with a total mineral content up to 300 to 500 milligrams per liter. Their pH rises to 7.0. In these waters, silica (SiO_2) occurs in amounts of 5 or 10 to 20 milligrams per liter, which is 2 to 18% of the total ions, and 10 or 20 to 2% of the total alkalinity. The bicarbonate ion (HCO_3) represents 50 to 70% of the total ions.

When the mineral content of the water increases to 1000 milligrams per liter and higher, the amount of silica decreases to 2 to 5 or 10 milligrams per liter. In these waters, the main constituents are the bicarbonates of Ca and Mg. Silica constitutes about 0.2 to 0.4% of the total ions. In waters containing sodium carbonate, silica is often almost completely absent (0 to 5 milligrams per liter) and always constitutes less than 1% of the total ions.

Thus, in proportion to the influx of ground water from the foothill region into the plains, and with increasing mineral content of the water, the silica gradually precipitates from the solution as a sediment which accumulates in the soil.

These data attest to the transportation by descending water of compounds of iron (0.5 to 1.0 milligrams per liter of Fe_2O_3) and of aluminum (0.05 to 0.02 milligrams per liter of Al_2O_3), in spite of the fact that their greater part has already precipitated from solution. Cases have been recorded in which the concentration of Fe_2O_3 in the soil and ground water rose to 40 to 100 and that of Al_2O_3 to 1.0 milligrams per liter.

The climate of the Amur foreland is characterized by a distinct overall predominance of evaporation over the amount of atmospheric precipitation (Table 2). In the annual average, the evaporation exceeds the total atmospheric precipitation by 30 to 50%, but, in separate ten-day intervals during the spring and summer months, by four to five times (12, 9). With a

TABLE 1

Chemical composition of ground and river waters in the Amur foreland
(in milliequivalents per liter)

Location and type of source	Elevation above the Amur	Date of analysis	pH	Alkalinity		Cl	SO₄	CA	Mg	Na	K	Excess	SiO₂	Fe₂O₃	Al₂O₃	Total ions, me.	% of total	
				CO₃	HCO₃					(spectrally)		HCO₃ me.					HCO₃	SiO₂
										Bicarbonate-silicate								
Spring Waters																		
Khey-khe town region, Chinese Democratic Rep.	IV–V	June 19, 1956	—	not found	0.52/ 32.0	not found	not found	0.19/ 3.8	0.07/ 0.9	0.19/ 4.4	0.07/ 2.9	None	1.00/ 32.1	0.45	0.05	76.0	42	42
Khey-khe town region, Chinese Democratic Rep.	"	"	—	"	0.52/ 32.0	"	"	0.33/ 6.6	0.05/ 0.6	0.11/ 2.7	0.03/ 1.0	—	0.67/ 21.4	—	—	64.3	74	50
Chernyayevo Field on the Amur River, USSR	"	July 6, 1956	6.5	"	0.40/ 25.0	"	"	0.11/ 2.2	0.06/ 0.7	0.06/ 1.4	0.03/ 1.0	0.13	0.33/ 10.7	—	—	41.3	60	26
Natal'ino village on Zeya River, USSR	"	Aug. 27, 1956	6.7	"	0.39/ 24.0	"	"	0.02/ 0.36	0.03/ 0.97	0.04/ 1.0	not found	0.30	0.67/ 21.4	0.45	0.02	47.7	51	45
Natal'ino village on Zeya River, USSR	"	"	6.0	"	0.39/ 24.0	"	"	0.05/ 1.06	0.08/ 0.97	0.10/ 2.23	0.03/ 1.0	0.13	0.67/ 21.4	0.72	0.02	50.7	48	42
Sukromli village, Amur-Zeya, watershed, USSR	"	Aug. 31, 1956	6.4	"	0.39/ 24.0	"	"	0.03/ 0.52	0.06/ 0.77	0.04/ 1.0	not found	0.26	0.50/ 16.01	0.45	0.02	42.3	58	40
Dzhalinda village, on the Amur, USSR	"	July 9, 1956	5.8	"	0.40/ 25.0	"	"	—	—	—	—	—	0.67/ 21.4	—	—	—	—	—
Soil and Ground Water																		
Meadow medium-thick soil, depth 100 to 130 cm.	III	June 19, 1956	—	"	0.72/ 43.9	0.04/ 1.4	"	0.12/ 2.24	0.13/ 1.56	0.32/ 7.4	0.18/ 7.2	0.01	0.67/ 21.4	1.5	0.09	85.1	50	24
Meadow medium-thick soil, depth 85 to 120 cm.	"	"	—	"	0.60/ 36.6	0.08/ 2.8	"	0.13/ 2.61	0.16/ 1.94	0.14/ 3.2	0.24/ 9.5	0.01	0.67/ 21.4	0.40	0.09	78.1	46	27
Brown forest podzolized soil	IV–V	July 1, 1956	6.2	"	0.41/ 25.0	not found	"	0.11/ 2.2	0.13/ 1.6	0.14/ 3.2	0.03/ 1.0	none	0.67/ 21.4	—	—	54.4	46	40
River Waters																		
Belaya River, Amur-Zeya watershed, USSR	III–V	Mar. 30, 1956	7.0	"	0.60/ 36.6	"	"	0.21/ 4.25	0.16/ 1.94	0.17/ 4.0	0.03/ 1.0	0.03	0.67/ 21.4	2.25	0.02	69.2	53	39
M.-Pera River, Amur-Zeya watershed, USSR	"	Aug. 31, 1956	7.0	"	0.60/ 36.6	"	"	0.07/ 1.42	0.13/ 1.52	0.12/ 2.8	0.03/ 1.0	0.25	0.67/ 21.4	1.20	0.02	64.7	38	33
										Silicate–Bicarbonate								
Amur River, Blagoveshchensk city, USSR	I	June 23, 1956	7.3	none	0.90/ 55.0	0.04/ 1.4	"	0.43/ 8.65	0.14/ 1.7	0.34/ 3.8	0.03/ 1.0	none	0.33/ 10.7	0.45	0.02	82.6	66	14
Zeya River, Blagoveshchensk city, USSR	"	Aug. 20, 1956	7.0	"	0.60/ 36.6	0.04/ 1.4	"	0.12/ 2.4	0.18/ 2.2	0.08/ 1.7	0.03/ 1.0	0.19	0.17/ 5.3	0.45	0.05	50.6	72	10
Sungari River, Harbin city, Chinese Democratic Rep.	"	Sept. 20, 1957	7.0	"	1.60/ 97.6	0.09/ 3.5	0.1/ 5.0	0.88/ 17.84	0.29/ 3.53	0.62/ 14.2	—	none	0.50/ 16.1	0.8	—	156.7	68	11

TABLE 1—*Continued*

Well Water																		
Sychevka, Amur-Zeya watershed, USSR	III	Aug. 28, 1956	5.8	"	0.61/ 37.0	0.09/ 3.5	not found	0.91/ 18.24	0.52/ 6.2	0.20/ 4.6	0.03/ 1.25	"	0.50/ 16.01	not found	0.02	86.8	42	18
Zarechnaya, Amur-Zeya watershed, USSR	II	Aug. 3, 1956	6.4	"	1.00/ 61.0	0.08/ 2.8	"	0.76/ 15.2	0.47/ 5.71	0.59/ 13.7	0.7/ 2.9	"	0.17/ 5.3	1.5	0.02	106.6	56	5
Dzhalinda on the Amur, USSR	"	July 9, 1956	6.8	"	3.11/ 220.0	2.0/ 71.0	0.52/ 25.0	3.49/ 70	1.15/ 14.0	1.0/ 23.0	0.44/ 17	"	0.67/ 21.4	—	—	461.4	47	4
Konstantinovka on the Amur, USSR	"	Aug. 21, 1956	6.4	"	2.98/ 181.0	0.08/ 2.8	not found	0.96/ 19.2	0.66/ 8.0	1.28/ 30.0	0.12/ 1.0	"	0.17/ 5.3	not found	0.02	247.3	73	2
	Bicarbonate (Soda and Soda-Sulfate)																	
Soil and Groundwater																		
Soda-solonchak, Chanlin district, Chinese Democratic Rep.	II	July 8, 1957	8.05	6.62/ 198.60	28.70/ 1750.70	0.46/ 16.29	trace	0.29/ 5.81	0.39/ 4.74	35.16/ 807.30	—	none	trace	not found	0.075	2783.5	63	0.00
Chlorine-soda solonchak, Chanlin district, Chinese Democratic Rep.	"	"	6.20	1.14/ 34.20	12.88/ 785.68	2.26/ 80.34	0.45/ 21.39	1.22/ 24.45	0.88/ 10.70	14.43/ 332.00	—	"	0.17/ 5.3	0.3	0.025	1388.8	61	0.41
Soda solonchak, Keyton district, Chinese Democratic Rep.	"	"	7.20	2.21/ 66.30	14.35/ 875.35	0.56/ 19.81	0.67/ 32.09	4.88/ 97.80	0.78/ 9.48	12.06/ 277.38	—	"	0.08/ 2.60	not found	0.01	1378.2	63	0.18
Soda-sulfate solonchak, Keyton district, Chinese Democratic Rep.	"	"	7.20	4.42/ 132.60	21.16/ 290.76	0.16/ 5.70	69.12/ 3317.5	1.46/ 29.26	7.81/ 94.97	85.50/ 1865.6	—	"	not found	trace	0.075	6736.4	19	0.00

TABLE 2

Atmospheric precipitation and evaporation in the Amur foreland, in millimeters

Months	Average 24-hr. precipitation by months	Average 24-hr. evaporation by months	Av. monthly precipitation for the 1913–1926 period	Ave. monthly evaporation	
				Pan	Ground water
	(data by P. I. Koloskov, 1925)		(data by Z. D. Klykov)	(data from the Hygrometric Service, 1956)	
January	0.1	0.1	—	—	—
February	0.17	0.20	—	—	—
March	0.13	0.7	—	—	—
April	0.6	2.1	—	—	—
May	1.0	3.6	32.3	94	93
June	2.7	2.8	90.6	100	105
July	2.8	2.4	104.7	119	106
August	3.3	2.3	86.6	98	90
September	2.1	2.4	64.4	78	75
October	0.4	2.1	13.9	35	25
November	0.3	0.3	—	—	—
December	0.12	0.1	—	—	—
Annual average	1.1	1.6	392	533	494
Ratio	—	—	1.0	1.4	1.3

total rainfall of 400 to 500 mm. (4500 to 5000 m.^{3} per hectare), and with an evaporation of about 600 to 700 mm. (6000 to 7000 m.^{3} per hectare), the moisture deficit owing to evaporation amounts to 150 to 200 mm. (1500 to 2000 m.^{3} per hectare). This deficit is covered by the evaporation and transpiration of soil and ground water. Since the soil and ground water of the alluvial plains of the Amur foreland is enriched by products of weathering and soil formation (either formed *in situ* or brought in by the seasonal influx of ground water) it is natural that its evaporation and transpiration should be accompanied by hydrogenic accumulations of these products in the soil horizons.

If each liter of ground water contains an average of 10 to 15 milligrams per liter of mobile SiO_2 (Table 1), and if the total of the soluble oxides of iron, aluminum and manganese constitutes about 1 milligram per liter, then the 1500 to 2000 m.^{3} per hectare of ground water which evaporates in the course of the year leaves behind on each hectare of soil 15 to 20 kg. of SiO_2 and 1.5 to 2.0 kg. of sesquioxides. Over a 10,000-year period this amounts to 150 to 200 metric tons of SiO_2 per hectare, and to 15 to 20 metric tons of hydrated oxides of iron, aluminum and manganese per hectare. Calculated as percentages of the weight of a soil layer one hectare in area and one meter deep this amounts to 1.0 or 2.0% of SiO_2 and 0.1 o 0.2% of $Fe_2O_3^+$ MnO_2^+ Al_2O_3.

The prolonged freezing of the Amur forelan soils, lasting up to 8 months, also disturbs the chemical equilibrium in the solutions, and as a result, the compounds of silica, iron, and aluminum may precipitate and accumulate in the soils as new formations.

As long ago as 1937, V. A. Kovda pointed out the role of migration and precipitation of silica compounds in solonetz soils. In 1940, 1946 and 1954, V. A. Kovda again discussed the phenomena of hydrogenic accumulations of sesquioxides and of silica (together with calcium carbonate, gypsum and readily soluble salts) in solonchak and meadow soils, under the conditions of hydromorphous soil formation in steppes, semi-deserts and deserts of the USSR.

Experiments by Sokolova (16) showed that, during the natural formation of the sedimentary rock minerals, the chemical synthesis of clay and of iron silicates and oxides frequently occurs.

The experiments of Yarilova and Parfenova (14) indicate the possibility of synthetic secondary minerals of the allophane type from solutions of silicon and aluminum compounds. It may be assumed that in nature such a synthesis takes place through the ionic forms of these compounds. The experimental work of Berestneva and Konstantinopol'skaya, carried out under the direction of Kargin (2), indicated that the formation of crystalline alumino-silicates from colloidal solutions takes place through true solutions. Yet, in these experiments the possibility of such new formations from substances soluble in the soil and ground water was not considered. Nevertheless, the hydrogenic synthesis of secondary soil minerals and clay formation in soil-forming rocks are both widely distributed under the hydromorphic conditions.

The data of Tables 3, 4 and 5 were obtained from investigations of siliceous and manganese-iron formations isolated from the horizons of Amur foreland meadow soils.

Alkaline extracts of siliceous grains showed that enormous amounts of silica, from 4 to 7 and even to 10% SiO_2, went into the 5% alkaline extract. We may assume that approximately one-third of this amount of silica is combined with alumina to form allophane of the type $2SiO_2$: $Al_2O_3 \cdot nH_2O$. The remaining two-thirds of the

TABLE 3

Content of amorphous silicate in siliceous grains, in percent

Material analyzed	Depth, cm.	SiO_2 in 5% KOH extract	Excess of SiO_2 compared to $2SiO_2:Al_2O_3$
Zeysko-Bureinsko-Amur plain, Profile 209	25–45	5.87	3.65
	55–65	10.42	6.91
Amur River flood-plain, II terrace	175	4.46	1.71
Profile 220	127–137	3.55	2.21
Profile 249	80–90	7.33	4.24
	140–150	9.17	6.58

TABLE 4

Analysis of opaline incrustations on 1 to 10 cm. rounded pebbles of meadow soils, in percent

Analytical procedure	SiO_2	Fe_2O_3	Al_2O_3
Extraction with 5% KOH	22.03	3.57	none
Insoluble residue	91.20	5.15	5.83
Same, calculated in terms of the original sample	35.16	1.99	2.24
Total	57.19	5.56	2.24

silica extractable with alkali, and in excess of the amount conventionally bound in the allophane of alumina, constitute the so-called "excess free" silica. The content of this last form of silica attains 2, 3, and even 7% of the mass of siliceous grains.

Clearly, the amounts of allophane and free silica dissolved by the alkali from the grains are extraordinarily large.

In the opaline formations on 1 to 10 cm. rounded pebbles deposited in the aquifers of meadow soils, silica constitutes 50 to 60% of the weight of the incrustation (Table 4).

These incrustations were typical opal, with separate pockets of chalcedony. It was evident that part of the silica had already crystallized and was not extractable by the alkali. Another part consisted of silicates of iron and aluminum. (These analyses were carried out by I. I. Feofarova, to whom the authors are highly indebted for her help.)

The concentration of these masses of allophanes and of free silica in the deep horizons (50 to 150 cm.) does not justify linking their genesis with solodization or podzolization. It is very clear that *in situ* accumulation of the hydrogenic type takes place here.

Study of the fractions of diameters 0.001 to 0.0003 and <0.0003 mm. of meadow soils from the basin of the Amur and Sungari rivers gave convincing confirmation that processes of hydrogenic accumulation of secondary minerals existed. (The profiles and the soil samples were collected by Prof. Sun Da-chen and V. A. Kovda; the analyses were performed in the Department of Soil Science, Moscow State University [E. A Kornblyum, V. I. Lyubimova, Ye. I. Bogoslovskaya, under the direction of Instructor N. G. Zyrin]. The authors are deeply grateful to N. G. Zyrin for analyses.) In all these soils profiles, the accumulation of significant amounts of amorphous mineral matter was verified. In the deeper horizons, where

TABLE 5

Data on total analysis and 10% HCl extract of iron-manganese concretions as percentage of the dry sample

Type of analysis	Size of concretion, mm.	Depth, cm.	Humus	SiO_2	SO_3	P_2O_5	Al_2O_3	Fe_2O_3	R_2O_3	CaO	MgO	MnO	Total
Total general analysis	2–2.5	0–20	1.09	37.28	0.60	0.51	20.98	10.83	32.32	5.93	1.55	13.31	101.12
	1–1.5	0–20	5.76	38.79	0.58	0.51	14.89	17.87	33.27	5.80	1.29	9.08	100.03
Analysis of 10% HCl extract	same	same	not detd.	0.25	0.60	0.51	14.94	10.43	25.88	2.44	0.82	13.31	not detd.
Percentage of total composition	same	same	not detd.	0.45	0.58	0.51	8.65	17.16	26.32	1.93	0.58	9.08	not detd.
Composition of residue after treatment with 5% KOH	same	same	"	0.67	100	100	71.21	96.30	80.07	41.14	52.90	100	"
	same	same	"	1.16	100	100	58.09	96.24	79.11	33.27	44.96	100	"
	same	same	"	29.08	not detd.	not detd.	6.04	0.40	6.44	3.49	0.73	not detd.	39.74
	same	same	"										
	same	same	"	29.54	"	"	6.24	0.71	6.95	3.87	0.71	"	41.07
				7.95			not determined						
Analysis of 5% KOH extract	same	same	"	8.80	"	"							

hydrogenic accumulation continued during longer periods, slightly- or well-crystallized minerals were more often found. Among the secondary minerals found there were also hydrous iron and aluminum oxides and (an especially important and interesting finding!) hydrargillite. One of the mineralogical analyses is presented below.

The accumulation of secondary minerals, that is, the conversion of alluvium into clay under the conditions of hydromorphous soil formation, is widely distributed throughout China and the Far Eastern USSR.

What other data may corroborate concepts of the hydrogenic origin of the new formations previously described: opaline incrustations, siliceous grains, allophanes and free silica, manganese-iron concretions, hydrargillite, hydrogoethite and others?

Data from the Mineralogical Analyses of Meadow-Gley Soils (Profile U-42)

Depth, cm.	Fraction 1–0.3 micron diameter	Fraction <0.3 micron diameter
2–9	Hydromica, kaolinite, amorphous matter. Finely dispersed kaolinite. Organic matter, some hydrogoethite, quartz, amorphous silica (diatom residues)	Finely dispersed kaolinite, intensively weathered hydromica, forming packs of mixed-lamellar composition; small amounts of hydrogoethite and hydrargillite, and a considerable amount of amorphous matter.
20–30	Considerable amount of hydromica largely converted to kaolin, halloysite, finely dispersed quartz, amorphous matter.	Mostly hydromica, admixture of halloysite and finely crystallized kaolinite, small amount of amorphous matter.
45–55	Composed of many minerals. Small amount of intensively weathered hydromica. Much mineral of the montmorillonite type (nontronite). Mineral hydroxides of iron and aluminum.	Similar to the preceding. Significant amount of hydromica, a little hydrogoethite and iron hydroxides; separate crystals of halloysite. Average amount of amorphous matter.
80–90	Composition like preceding sample. Less hydroxides of iron.	Composition like preceding sample, but considerably more hydroxides of iron and amorphous (allophane) matter. Possible presence of montmorillonite minerals.
210–230	Considerable amount of amorphous allophane, iron of hydroxide (hydrogoethite), intensively weathered hydromica, halloysite, quartz.	Weakly crystallized montmorillonite mineral, considerable amount of hydromica, halloysite, finely dispersed quartz. Allophane with well-crystallized iron hydroxide (hydrogoethite).

The accumulation of siliceous grains in meadow soils is mainly at depths of 100 to 170 cm. This is the horizon lying at the level of soil and ground water supplied by the frozen stratum. Siliceous grains are not usually observed below this depth. Calculations of the amount of manganese-iron concretions taken from various horizons of meadow soils give a clear picture of their hydrogenic accumulation with a maximum at the upper horizon where the processes of evaporation and oxidation are most pronounced (Fig. 1). Such a distribution of concretions is observed also in gley-meadow soils of Northeastern China (Fig. 2).

In the hydromorphic desert soils, a similar type of profile distribution of new formations is recorded for easily soluble salts, gypsum and calcium carbonate. In the Amur foreland this role corresponds to secondary compounds of iron, aluminum, manganese and silica.

Brown forest soils, which have developed in landscapes of the Amur foreland where the products of weathering and soil formation are largely leached away, do not have a profile characterized by the hydrogenic accumulation of sesquioxide new formations (Fig. 1). Although a small quantity of manganese-iron concretions is found in the profile of brown forest soils, their content is extremely small and their distribution clearly shows the leaching away of iron and manganese compounds.

The differentiation of zones of sesquioxides accumulation, allophane and free silica along the soil profile also points out the effect on the evaporation of soil and ground water. Silica, allophane and crystallized montmorillonite accumulate mainly in the lower part of the profile of meadow soils, because they precipitate from solutions in one of the first stages in the differentiation of chemical deposits in the weathering crust (17, 15, 7, 5). Compounds of reduced iron and manganese in the form of capillary solutions, and part of the silica and alumina migrate to the superficial horizons and are deposited mainly in the 0 to 30 cm. horizon, which undergoes the most intensive drying and aeration. Visible traces of the migration of iron in solutions may be followed in sections under the microscope. In them, the large fissures and cavities are the least ferruginated of all, while cavities of the capillary type have been subjected to ferrugination.

Mineralogical analysis of manganese-iron con-

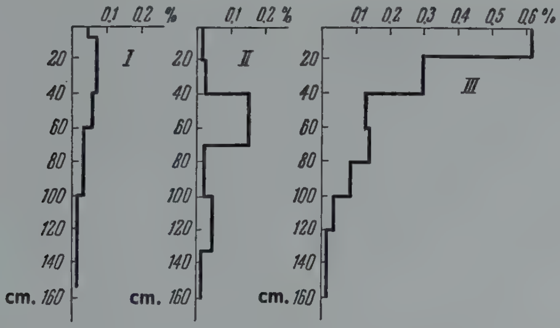

FIG. 1.—Content of Fe and Mn in concretions found in soils of the Amur foreland (as % of the soil weight). I—Brown forest soil, not podzolized; II—brown forest soil, podzolized; III—thick meadow soil.

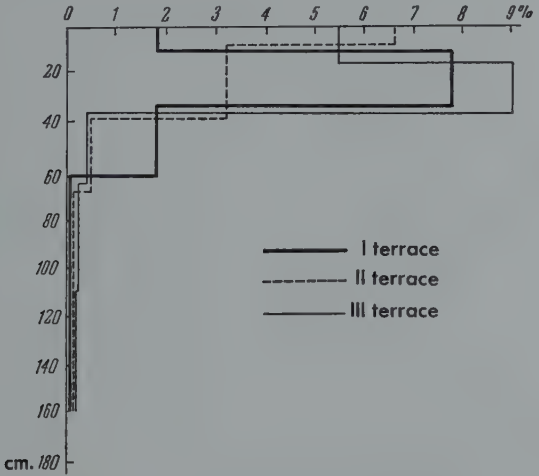

FIG. 2.—Content of Fe and Mn concretions found in gley-meadow soils of the Ussuri river terraces (as percentage of the soil weight). Compiled from data by Prof. Tsin.

cretions showed that the largest concretions, which attain a diameter of 2 to 2.5 mm., consist chiefly of hydrogoethite (a hydrous form of iron oxide). Small iron concretions (1 to 1.5 mm. in diameter consist mainly of compounds of the manganese oxide type and of black carbon-like particles.

A microscopic examination of the residue after treatment of the concretions with 10% HCl indicated that this insoluble residue contained much opal, fragments of feldspar, epidote, quartz, hornblende and, rarely, fitalitarite. (The mineralogical analyses were performed in the Soil Institute, Academy of Sciences, USSR by E. A. Yarilova, to whom the authors convey their gratitude.)

In the total analysis of the concretions it is important to note the presence of 1.0 to 5.7% of humus, 37 to 38% of SiO_2, 32 to 33% of sesquioxides, and also of 9 to 13% of manganese oxides. Thus, up to 50% of the mass of the concretions consists of oxides of aluminum, iron and manganese, with an admixture of humus. Manganese, iron and a considerable part of the aluminum went almost completely into the 10% hydrochloric acid extract (Table 5).

It is very important that the average ratio of the weight of the concretions of sesquioxides to the "amorphous" siliceous grains is close to the order of the ratios of the sums of sesquioxides to the silica in ground waters: in the soil 1:10 to 22, in ground water 1:10 to 22 (Table 6).

TABLE 6

Magnitude of the ratios between concretions and SiO_2 grains in the soil, R_2O_3 and SiO_2 in ground water

Profile No.	In grains and soil		
	% amorphous SiO_2 in siliceous sprinkling	% concretions in soil	Ratio $\frac{\text{concretions}}{\text{amorphous } SiO_2}$
209	6.48	0.3	1/22
249	6.58	0.6	1/10
220	2.21	0.2	1/11
Profile No.	**In ground waters**		
	Dissolved SiO_2, mg./liter	Total sesquioxides, mg./liter	Ratio of the total $\frac{Fe_2O_3 + Al_2O_3}{SiO_2}$
209	21	1.6	1/13
249	5	0.5	1/10
220	11	0.5	1/22

TABLE 7

Content of amorphous SiO_2, in percent, in a meadow soil of the Amur foreland, according to data from a 5% KOH extract

No.	Depth of sample, cm.	Hygroscopic moisture, %	SiO_2	Al_2O_3	Fe_2O_3	2 SiO_2: Al_2O_3		Residue of SiO_2 compared with 2 $SiO_2Al_2O_3$
						In me.	In %	
249	0–5	4.62	1.73	0.725	0.055	0.0149	1.65	0.0073
	5–15	3.78	1.63	0.998	0.039	0.0195	2.17	0.0037
	20–30	3.38	1.26	1.036	0.039	0.0203	2.25	0.0003
	40–50	4.30	1.05	1.020	0.023	0.0175	1.05	none
	60–70	4.43	1.19	1.190	0.023	0.0198	1.19	"
	80–90	4.29	1.25	1.093	0.023	0.0208	1.25	"
	140–150	4.08	1.32	0.987	0.023	0.0193	2.15	0.0013

With the increase in the amount of amorphous free silica, a tendency to an increase in the amount of concretions in the upper soil horizon is detected. This also indicates that the accumulations of secondary compounds of silica, of sesquioxides and of products of their interaction are genetically linked to the soil and ground water and to the loss of such water by evaporation and transpiration.

Direct alkaline extracts of soil samples (throughout the whole soil profile) gave practically no free silica (amorphous SiO_2; Table 7). Consequently the process of meadow soil formation with a superficial water table does not by itself contribute toward the disintegration of alumino-silicates and the liberation of silica. On the contrary, the grains made up of secondary compounds of silica and allophane are sediments which have been separated from the soil and ground water.

The forms in which these compounds migrate still remain unknown. The subject requires special research. However, inasmuch as the methods for determining the content of iron, aluminum and silica in water take into account their ionic soluble forms, we are inclined to consider precisely these forms as fundamental under the given conditions. (Note: SiO_2 was determined by the colorimetric method of Dienert-Wandenbulcke, Fe_2O_3, by the thiocyanate method, and Al_2O_3 by the hematoxyline colorimetric method). But this does not exclude the possibility that these compounds may migrate in the form of colloidal solutions or complex compounds.

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INFLUENCE OF EUROPEAN LARCH ON CHANGES IN SOD-PODZOLIC SOILS

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A NUMBER of investigators (20, 12, 13, 16, 17, 18, 4, 9, 6, 10, 2) have noted the favorable influence of the larch on the physical and chemical properties of soils, although several authors consider that it produces an unfavorable influence. Aaltonen (12), Sukachev (7), and Wittich (23) observed that the larch changes soils very slightly and that its influence is doubtful. Most investigators believe that the spruce causes podzolization of the soil (19, 21, 15, 11, 14, 18, 3, 9). However, Wittich (22) observed that nowhere in Germany had he noticed podzolization beginning under pure spruce forests.

It would seem, therefore, that the influence of the larch on soil change is not clear and has not been adequately investigated. Studies conducted in this direction are of considerable scientific and practical importance because the larch is invading more and more into the forests of the European part of the SSSR.

Our investigations were conducted in the Lithuanian SSR where considerable attention is given to growing larch. For comparison, the influence of the larch on soil changes was studied in pairs of larch and spruce plantations of approximately the same age and site quality growing in Sod-podzolic soils of various textures.

A brief evaluation of the characteristics of the plantations studied is presented in Table 1.

The soil textures under the larch and spruce plantations differed. In tracts I and III the soils were of loamy sand to a depth of 60 to 70 cm.; in tract I this was underlain by morainic clay loam, and in tract III, by clay. In tract II the soils from the surface to a depth of 40 cm. were of sandy loam; below that they changed into clay loam. Tract I was located in a region with somewhat undulating terrain, tract II on a level area, and III had a slightly undulating surface.

To detect differences in the influence of the larch and the spruce on the soil, studies were made by ash composition of coniferous needles, fallen leaves and litter of these species (as indices of the rate of the cycle of ash substances between tree stands and soils), amount and rate of decomposition of litter, and changes in some of the physical and chemical soil properties.

The larch and spruce (Table 2) were similar in the total ash content of the needles (excluding the amount of impurities, the ash content of the larch and spruce needles amounted to 5.98% and 5.74%, respectively), but they differed substantially in the composition of ash elements. The larch needles contained more iron and aluminum sesquioxides and P_2O_5 and K_2O. The amount of MgO was also somewhat greater than in the spruce. The spruce needles yielded a significantly greater amount of SiO_2 and larger accumulations of CaO, MnO, and SO_3.

We can conclude that the larch, using larger amounts of P_2O_5, K_2O and iron and aluminum sesquioxides and since it annually sheds all its needles, should enrich the soil. The spruce chiefly intensified the SiO_2 and CaO cycles. However, in the spruce plantations there was almost twice as much shedding on the soil surface every year as in the larch plantations (Table 3).

The differences in the dynamics of the intake and total amount of shedding were due to the thicker, more densely needled crown of the spruce, but a slight increase in shedding by the spruce in 1955 was explained by the dryness of the growing period.

Of the total shedding, the following are the amounts of the 2 types of needles:

Tree species	*Age of plantation*	*Quantity*
Larch	20 years	2440 kg. per ha.
Spruce	30 "	3541 "
Larch	105 "	1366 "
Spruce	95–100 "	3420 "

The larch needles contained a large amount of ash elements, but since the total amount shed in the larch plantations was less than in the spruce plantations, the consumption and return of these elements per unit area was less. Before proceeding to an examination of these data, let us turn to the data on the ash composition of the leaf-fall reaching the soil surface (Table 4).

TABLE 1

Evaluation characteristics of larch and spruce plantations per hectare

Tract	Site of investigation	Composition	Age of plantings	Forest types	Forest species	Averages of principal species		Number of trees	Total wood content, m³	Crown density	Site quality of principal forest species
						Height, m.	Diam., cm.				
I	Mazheykiya forest quart. 155	8 larch 2 spruce + pine + alder	20	Larch, wood sorrel, blueberry	Larch	11.2	10.7	2870	163	0.93	I-a
	Same	10 spruce + pine	30	Spruce, wood sorrel, blueberry	Spruce	12.8	12.0	2540	227	1.10	I
II	Zagoiya forest quart. 32	9 larch 1 pine + spruce	25	Larch, wood sorrel	Larch	16.5	19.5	1180	239	1.00	>I-a
	Same	10 spruce	105	Spruce, wood sorrel	Spruce	16.0	18.2	1090	262	0.98	I-a
III	Degsnes forest quart. 29	9 larch 1 spruce + pine	105	Larch, wood sorrel	Larch	41.0	47.2	676	1233	1.84	>I-a
	Degsnes forest, quart. 27	10 spruce + pine	95–100	Spruce, wood sorrel	Spruce I story	35.0	49.8	152	483	0.67	I-a
		10 spruce + pine	50		Spruce II story	20.0	19.0	376	104	0.34	I-a
						I+II story		528	587	1.01	I-a

The ash content of the spruce litter (without impurities) was not large and was lower than the data reported by Zonn (5). In comparison with the live needles (Table 3), only the amounts of SiO_2, Fe_2O_3, and Al_2O_3 were increased in the needles shed by the larch and spruce. The remaining oxides decreased, apparently as a result of their outflow to the wood and roots.

As the larch plantations aged, there was a decrease in the content of all the ash elements of the leaf-fall except SiO_2, MnO, K_2O and SO_3. Amounts of the latter elements usually stayed at the same level owing to a change in the fractional composition of the leaf-fall. As the spruce plantations aged, the only increases were in SiO_2 and K_2O content, while the amounts of the remaining ash elements decreased.

When an estimate was made of the total leaf-fall of larch and spruce needles reaching the soil surface per year, there was an even sharper difference in the ash composition (Table 5).

There were only about half as much of the ash elements in the leaf-fall under the larch plantations as those under the spruce. Thus, from the leaf-fall of the 20 to 30-year-old larches there

TABLE 2

Ash composition of larch and spruce needles in Tract I

Tree species	Ash content, %	Am't of impurities, %	SiO_2	CaO	MgO	R_2O_3	Fe_2O_3	Al_2O_3	P_2O_5	MnO	K_2O	SO_3
			As % of oven-dry material									
Larch	6.70	0.72	0.35	0.78	0.44	1.15	0.06	0.32	0.77	0.06	2.43	0.24
Spruce	6.22	0.48	1.99	1.13	0.32	0.52	0.03	0.13	0.36	0.09	1.79	0.40

TABLE 3

Dynamics of the accumulation of needles under larch and spruce plantations in kg. per ha. of oven-dry weight

Tract	Kind of wood	Age of plantation	Months						
			June	July	August	Sept.	Oct.	Nov.–May (Totals)	Totals
I	Larch	20	168	86	251	355	443	2030	3433
	Spruce	30	122	174	648	924	981	3286	6135
III	Larch	105	465	93	245	349	938	1500	3590
	Spruce	95–100	183	347	562	699	766	3885	6442

TABLE 4

Ash composition of leaf-fall and litter of larch and spruce as percentage of oven-dry weight

Tract	Tree species and age	Substance	Ash, %	Impurities, %	SiO_2	CaO	MgO	R_2O_3	Fe_2O_3	Al_2O_3	P_2O_5	MnO	K_2O	SO_3
I	Larch	Leaf-fall	7.90	3.75	0.58	1.09	0.25	0.97	0.24	0.45	0.28	0.09	0.73	0.30
	20 yr.	Litter	44.88	36.74	1.24	1.38	0.32	2.10	0.59	1.25	0.26	0.15	0.53	0.43
III	Larch	Leaf-fall	6.55	2.59	0.59	0.92	0.19	0.43	0.09	0.22	0.12	0.10	0.62	0.37
	105 yr.	Litter	14.89	8.84	1.84	0.94	0.26	0.56	0.11	0.30	0.15	0.19	0.46	0.34
I	Spruce	Leaf-fall	8.56	3.80	2.16	1.05	0.18	0.55	0.17	0.22	0.16	0.11	0.54	0.35
	30 yr.	Litter	32.78	25.49	2.60	1.24	0.21	1.16	0.27	0.70	0.19	0.18	0.48	0.55
III	Spruce	Leaf-fall	7.44	3.41	2.34	0.75	0.17	0.46	0.10	0.20	0.16	0.11	0.73	0.35
	95–105 yr.	Litter	25.65	17.25	3.87	1.02	0.23	1.33	0.38	0.58	0.17	0.20	0.37	0.55

TABLE 5

Amounts of ash elements reaching the soil annually with leaf-fall in young and mature plantations of larch and spruce in kg. per ha.

Tract	Tree species	Total leaf-fall, kg.	SiO_2	CaO	MgO	R_2O_3	Fe_2O_3	Al_2O_3	P_2O_5	MnO	K_2O	SO_3
I	Larch	3433	18.89	37.41	8.58	33.30	8.24	15.45	9.62	3.09	25.06	10.30
	Spruce	6135	132.52	64.42	11.04	33.74	10.43	13.50	9.82	6.74	33.13	21.47
III	Larch	3590	21.18	33.03	6.82	15.44	3.23	7.90	4.31	3.59	22.26	13.28
	Spruce	6442	149.81	48.32	10.95	29.63	6.44	12.88	10.31	7.09	47.03	22.55

was 172 kilograms per hectare of ash elements (tract I); from spruce of the same age there was 327 kilograms per hectare of ash substance; under 95 to 105-year-old plantations of these species there were 131 and 344 kilograms per hectare, respectively. With increasing age of the larch the amount of ash substances accumulating in its leaf-fall, especially of Al and Fe sesquioxides and P_2O_5, decreased sharply (only SiO_2 and SO_3 increased slightly); the spruce, on the other hand, showed increases principally in SiO_2 and K_2O, and slightly in P_2O_5 and SO_3.

For the soils to fix these compounds special importance rests not only on the amount of organic substances occurring with the shedding, but also on the character and rate of its decomposition and the makeup of the decomposition products. Table 5 shows that 3264 kilograms per hectare of organic matter fell on the soil under the larch on tract I and 3459 kilograms per hectare on tract III. Under the spruce there were 5808 and 6038 kilograms per hectare, respectively (without ash substance).

Somewhat more of the ash substances accumulated in the litter (Table 4) than in the leaf-fall. Thus, excluding the impurities, the ash content of the larch litter on tract I reached 8.14% and on tract III, 9.05%. Under the spruce the ash content was 7.29% and 8.40%.

Judging by the amount of litter during the growing period (Table 6), decomposition proceeded considerably more intensively under the larch than under the spruce (by July 13 there was a 17% decrease in the former and an 8% decrease in the latter).

Decomposition also continued later but was concealed by the fall accumulation of new leaf-fall. Of course, the shedding rate was higher under the larch than under the spruce. Data from determinations of CO_2 liberated from the litter surface indicate that its decomposition was more intensive under the larch than under the spruce (Table 7).

One and a half times as much CO_2 was liberated from under the larch as from under the spruce. In addition, the amount of CO_2 increased under the larch until August 11, but under the spruce the maximum CO_2 was reached on July 17 after which there was a sharp drop. Such a marked difference in the liberation of CO_2 depended not only on the quality of the decomposing materials but on the decomposition con-

TABLE 6

Dynamics of decomposition of litter under larch and and spruce plantations on Tract I in kg. per ha.

Date of determination	Larch (20 year)		Spruce (30 year)	
	Air-dried weight of litter	Difference after period between determinations	Air-dried weight of litter	Difference after period between determinations
May 11	7100	—	16060	—
July 13	5860	−1240	14780	−1280
Sept. 9	6140	+280	14960	+180
Oct. 27	7320	+1180	15680	+1720

TABLE 7

Dynamics of CO_2 liberation during decomposition of forest litter on Tract I in kg. per hour

Date of determination	Time of determination	Larch	Spruce
May 20	13.45	3.66	2.57
July 17	11.20	4.07	3.30
Aug. 11	11.15	4.77	2.93
Sept. 14	11.00	2.58	1.82

ditions as well. Better conditions were created under the larch canopy than under pine for decomposing action of animals and microorganisms because of more intensive exposure to light of the litter surface, more favorable humidity and temperature conditions. In addition, the increased amount of CO_2 liberated in the larch area showed more active photosynthesis than in the spruce area.

The ash composition of the litter also corresponded to the dynamics of its decomposition and accumulation (Table 8). The total supply of ash elements was substantially higher in spruce than in larch litter. In the spruce litter there were increases especially in SiO_2, CaO, Al_2O_3, P_2O_5, K_2O, and SO_3.

In spite of the fact that there was considerably less litter under the larch it contained almost the same amount of iron and aluminum as the spruce litter. This must not be associated with the depth of spreading of the larch roots. Many of them penetrated into horizon B, which had a high content of these elements. It was difficult to decide whether increases in Fe and Al in the leaf-fall and litter were caused by biological properties of these species, but such an intensified circulation of these ash elements in the tree-to-soil cycle undoubtedly exerted a great influence on the soil.

The mobility or rate of leaching of the ash elements from the litter is very important in soil formation. With more rapid decomposition of the litter under the larch plantation, its ash substances were circulated more rapidly in the tree-to-soil cycle than under spruce. This was critically important in the change in the genetic and forest vegetation properties. As seen from Table 9, the pH values of the soils under the larch were less acid on all three tracts; the amount of exchangeable Ca^{++} and Mg^{++} was three to five times higher there than in soils under the spruce, and a very marked biological accumulation was observed in horizon A. Especially notable was the accumulation of exchangeable Mg^{++}, which agreed fully with the ash composition of the leaf-fall and litter and confirmed the great capacity of the larch to absorb this element selectively. Owing to the high content of Ca^{++} and Mg^{++} in the adsorbing complex the amount of exchangeable hydrogen and aluminum decreased sharply in soil under the larch.

The biological accumulation was expressed very weakly in soils under spruce; an intensive leaching of the exchangeable Ca^{++} and Mg^{++} predominated there, as shown by their increase with depth down to the carbonate-rich horizons. The degree of saturation also increased in the same direction. Nonsaturation was determined not only by the hydrogen but also by the aluminum, the amount of which was

TABLE 8

Quantity of ash elements in larch and spruce litter on Tract I in kg. per ha.

Tree species	Date of determination	SiO_2	CaO	MgO	R_2O_3	Fe_2O_3	Al_2O_3	P_2O_5	MnO	K_2O	SO_3
Larch	May 11	79.52	89.46	20.59	135.61	37.63	80.94	17.04	9.94	34.08	27.69
	Oct. 27	81.98	92.23	21.23	139.81	38.80	83.45	17.57	10.25	35.14	28.55
Spruce	May 11	375.80	179.87	30.51	168.63	38.54	99.57	27.30	25.70	69.06	80.30
	Oct. 27	366.91	175.62	29.79	164.64	37.63	97.22	26.66	25.09	67.42	78.40

TABLE 9

Change in some physicochemical properties of soils under larch and spruce in oven-dry weight

Tract	Tree species	Depth, cm.	Humus, %	Actual pH	Exchangeable cations in me. per 100 gm. of soil			Total exchangeable cations	As % of total cations			Al^{+++}, me. per 100 gm. soil	Hydrolytic acidity, me. per 100 gm. of soil	Degree of saturation by cations (according to hydrolytic acidity)
					Ca^{++}	Mg^{++}	H^+		Ca^{++}	Mg^{++}	H^+			
I	Larch	2–10	1.68	5.60	7.78	2.88	0.56	11.22	69	26	5	0.04	3.18	77
		20–25	0.80	5.65	4.03	0.90	0.00	4.93	81	19	0	0.12	2.30	68
		40–40		5.92		*Not determined*								
		60–70	0.16	7.15										
	Spruce	3–10	1.43	4.25	1.62	0.82	3.89	6.33	26	13	61	2.60	9.48	21
		20–30		4.75		*Not determined*								
		35–45	0.27	5.65	5.97	2.55	0.12	8.64	69	30	1	0.03	1.42	86
		60–70	0.30	7.02		*Not determined*								
II	Larch	2–10	3.09	4.77	10.42	4.93	0.69	16.04	65	31	4	0.02	4.49	77
		15–25	1.20	4.74	4.42	2.22	0.68	7.32	60	30	10	0.20	3.20	69
		30–40	0.36	4.75	4.09	4.11	0.52	8.72	47	47	6	0.25	2.59	76
		50–60	0.41	5.20		*Not determined*								
		70–80		5.40	9.01	6.50	0.12	15.63	57	42	1	0.01	1.34	92
		100–110		7.12		*Not determined*								
	Spruce	2–10	1.93	4.05	2.81	1.64	4.57	9.02	31	18	51	1.28	5.80	44
		10–20	1.10	4.10	1.69	0.61	3.26	5.56	30	11	59	1.12	3.89	37
		20–30	0.42	4.29	1.95	1.02	0.87	3.84	51	27	23	0.51	3.01	50
III	Larch	4–10	1.18	5.05	3.59	1.16	0.64	5.39	67	21	12	0.09	3.18	59
		15–25	0.73	5.10	2.09	0.66	1.24	3.99	52	17	31	0.59	2.83	49
		50–60	0.01	5.05	2.74	0.33	0.20	3.27	84	10	6	0.12	1.05	75
		70–80		5.80										
		100–110		7.18		*Not determined*								
	Spruce	4–10	2.48	4.09	3.26	1.23	6.77	11.26	29	11	60	2.60	17.21	21
		10–15	2.30	4.15	1.85	0.41	5.94	8.20	23	5	72	3.49	12.35	15
		30–40	0.19	4.82	2.58	0.58	0.45	3.61	71	16	13	0.41	2.28	58
		50–60	0.28	5.86										
		80–90		7.02		*Not determined*								
		100–110		7.03										

markedly increased in comparison with the soil under the larch.

As a result of the changes in the composition of the exchangeable cations, the properties of horizon A_2 were also substantially changed in the soils under the larch. Thus, on tract II the degree of cations saturation in horizon A_2 (at a depth 15 to 25 cm.) reached 69%, while in the soil under the spruce it amounted only to 37%. On tract III this difference was expressed still more sharply: under the spruce it was 15%, and under the larch, 49% (at depths of 10 to 15 and 15 to 25 cm.).

An increase in the amount of humus was also noted in the soils under larch. Only on tract III was there any variation; this was probably related to the friability of the soil surface. Such substantial changes in the soil properties fully agree with the data on the ash composition of the leaf-fall and litter and their decomposition rate. This supports the belief in the more aggressive character of organic acids which are formed with disintegration of organic substances accumulating under the spruce.

Judging by the change in the soil properties under larch and the structure of its profile, we are inclined to assume that under our conditions sod-podzolic soils evolve fairly rapidly in the direction of the brown forest soils of northern Germany described by Ewald and other investigators. Such rapid evolution is undoubtedly closely related to the high content of morainal carbonate clay loams in the underlying soils. Mobilization from them of Ca and other ash substances was produced by the larch to an immeasurably greater extent than by the spruce, owing to the difference in the branching and to the depth of root system penetration. The larch roots have a clearly expressed vertical branching and penetrate to a depth of 2 to 3 meters or even further. Thus, on tract III at a depth of 2 meters, roots were observed with a diameter of 2 to 3 cm. The root system of the spruce has a horizontal branching; the roots do not extend deeper than 40 to 60 cm., and most of them are located in the upper 10 to 20 cm. of the soil. It is precisely this which explains the high wind-firmness of the larch on these soils and the low wind-firmness of the spruce. Under spruce the circulation of nutrient matter is limited by the thin layers. At the same time during some periods leaching may predominate over accumulation, causing podzolization of the soil.

The fact that the larch and spruce were substantially different in their influence on the physicochemical soil-properties was also confirmed by changes in their physical properties. Under the larch, microaggregation (Table 10) was somewhat better in the upper 25 to 30 cm. of the soil. Here, in comparison with that under spruce, the number of microaggregates measuring from 1 to 0.25 mm. diameter and from 0.25 to 0.05 mm. diameter increased. However, these shifts were not so significant. The soil under the spruce in tract III was an exception: here the microaggregates were sharply reduced from 1 to 0.25 mm. diameter, probably owing to dispersion resulting from the high content of exchangeable H^+ and Al^{+++}.

The bulk density (Table 11) in the upper 40 to 50 cm. layer was lower under spruce than under larch. This correlated fully with the maximum accumulation here of spruce roots and with the large amount of semi-decomposed organic residues down to a depth of 10 cm. Therefore, at this depth soil pore space was somewhat higher under spruce than under larch (Table 11).

Such a change in the bulk density and pore space also corresponded to the permeability to water at different soil depths (Fig. 1). The permeability from the surface of the soil was higher under spruce than under larch in the first two hours. Thereafter, apparently after swelling and repacking of the particles, it approximated that under larch. At a depth of 20 cm. and especially 50 cm. larch had more large roots, and, consequently, the permeability of the soil became higher under larch.

Thus, better conditions were created for the soils to soak up and dissolve the carbonates below 60 to 70 cm. because of the greater permeability of these soils under larch. This made possible not only greater absorption of Ca by the roots but also neutralization of organic acids which had entered the soils along with the moisture. Under spruce it is more probable that the moisture was retained on the surface of the morainic carbonate clay loams, which caused its temporary stagnation and its greater destructive action on the mineral part of the upper soil layer.

These factors naturally promoted an increase in the leaching of Ca and other ash substances from the upper horizons and facilitated the saturation of the latter with exchangeable H^+ and Al^{+++}. Their lateral rather than vertical migration held back the outflow of excess water.

TABLE 10

Structural composition of the soil (according to N. A. Kachinskiy)

Tract	Tree species	Depth, cm.	Amount of fractions (mm. in diameter) in percent of oven-dry soil						Total particles of <0.01, %
			1–0.25	0.25–0.05	0.05–0.01	0.01–0.005	0.005–0.001	<0.001	
I	Larch	2–10	18.20	62.19	15.92	1.71	1.33	0.65	3.69
		20–25	19.93	60.29	14.14	2.82	2.09	0.73	5.64
I	Spruce	3–10	15.53	61.82	18.27	2.37	1.11	0.90	4.38
		35–45	10.03	61.75	14.30	3.22	5.78	4.92	13.92
II	Larch	2–10	18.22	56.71	18.92	2.33	2.63	1.19	6.15
		15–25	14.75	54.71	20.36	4.24	3.44	2.50	10.18
III	Larch	4–10	14.61	68.22	14.95	1.37	0.29	0.56	2.22
		15–25	14.78	69.29	13.27	1.09	0.81	0.76	2.66
III	Spruce	4–10	7.55	71.31	19.17	0.33	0.57	1.07	1.97
		30–40	2.59	77.67	17.65	1.65	0.20	0.24	2.09

TABLE 11

Changes in the bulk density and pore space of soils under larch and spruce

Tract	Tree species	Depth, cm.	Bulk density of soil, gm. per cm.^{3}	Particle density of soil	Pore space, %
I	Larch	2–10	1.24	2.36	47.5
		20–30	1.57	2.37	33.8
		40–50	1.74	2.41	27.8
I	Spruce	3–10	1.13	2.30	50.9
		20–30	1.34	2.38	43.7
		40–50	1.56	2.40	35.0
III	Larch	4–10	1.36	2.53	46.2
		10–20	1.52	2.51	39.5
		30–40	1.59	2.52	36.9
III	Spruce	1–10	0.67	2.22	69.8
		10–16	1.13	2.44	53.7
		30–40	1.48	2.47	47.8

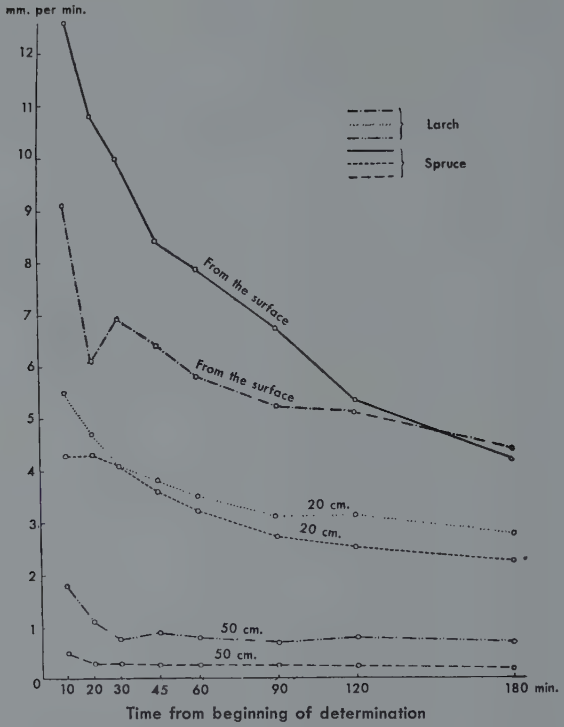

FIG. 1—Water permeability of soils in larch and fir plantations (Mazheykiya forest, quart. 155)

Conclusions

1. The distinctly positive influence of the European larch on sod-podzolic soil began to appear with 20 year old plantations.

2. It was manifested by an intensified circulation of ash substances between the leaf-fall and litter and the soils, inasmuch as decomposition of the litter of the European larch proceeded more actively than that of the spruce.

3. The ash elements, especially Ca and Mg, set free by the decomposition of organic substances, were fixed to the adsorbing complex of the soil, which caused the sharp rise in their saturation and the lowering of the acidity.

4. Because the larch roots penetrated deeper into the soil than those of the spruce, the permeability of soil under larch was improved, and made possible both greater mobilization of Ca from the litters of morainic carbonate clay loams or clays and also neutralization of the organic acids formed during decomposition of the litter.

5. The circulation of matter in the soils under spruce was limited to a depth of 50 to 60 cm., and the ash substances were subjected to considerably greater leaching and saturation by hydrogen and aluminum. Consequently, podzolization was intensified and there was a secondary biological accumulation of SiO_2.

6. Under larch plantations horizon A_2, owing to a greater secondary saturation, lost the characteristics and properties typical of podzolic soils.

7. The observed changes in the coarse-textured sod-podzolic soils which developed on the finer morainic carbonate clay loams allow us to conclude that under the influence of larch these soils evolved toward brown forest soils.

8. As a result of the change in properties of the sod-podzolic soils under larch plantations, their soil fertility also improved, assuring the growth of plantings of site quality class I and Ia.

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CHARACTERISTICS OF SOIL FORMATION UNDER FOREST AND PLOWED LAND IN KALININGRAD REGION

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The object of the present work is the characterization of the various processes of soil formation in both forest and cultivated sod-podzolic soils.

The work was carried out in the southwestern part of Kaliningrad region on the Pravdinsk-Chernyakhovsk glacio-lacustrine plain. The soils of the tract on which the experimental plots were established are sod-podzolic and are made up of a three-layer deposit: a thin clay loam underlain by clay which lies, in turn, on a morainic clay loam. In spite of the plains-type topography of the tract, its soil cover is heterogeneous. This is related to the heterogeneity of the soil-forming deposits. The thickness of the individual deposits also varies considerably over very short distances. The clay loam layer varies from 12 to 40 cm., the clay from 40 to 150 cm. The clay, and also the morainic clay loam underlying it, do not consist of homogeneous deposits but abound in sandy lenses and streaks. The presence of carbonate inclusions is characteristic of the clay and underlying clay loam. The lower boundary for the occurrence of carbonates is uneven and goes down to a depth of 80 to 100 cm.

Within the tract two plots were established, one on forest and one on cropland.

The forest plantation was a green-moss spruce forest of 60 years' growth. Under the forest was sod-strongly podzolized soil with slight signs of gleying, described by the following morphological features:

Horizon A_0 0–7 cm. A layer of matted forest debris made up of half-decomposed fragments of coniferous needles, twigs, and leaves; in the bottom part was a considerable admixture of soil particles.

Horizon A_1/A_2 7–14 cm. Friable clay loam of a dark, almost black color, in a moist condition but which turns quite gray when dried; it contained many coarse quartz grains.

Horizon A_2 14–25 cm. Light-gray clay loam of laminated structure with darker additions of humus; it contained numerous fine rusty grains of ortstein.

Horizon A_2/B 25–38 cm. Brown clay loam of heterogeneous coloration with gray podzolized patches and ocherous stains on the surface of cloddy structural fragments.

Horizon B/D 38–81 cm. Cinnamon-brown clay, compact, with numerous streaks of manganese.

Horizon D 81–150 cm. Gray clay loam with inclusions of cinnamon-brown clay and scattered gleyed patches; a large quantity of carbonate inclusions appear, especially below 129 cm.

The plowed plot was located 200 to 250 meters from the edge of the forest. We do not know exactly when this region was put under cultivation, inasmuch as all the cultivated sections in the Kaliningrad region are drained, and the drain was laid in the years 1927–1929. Apparently this territory was only put under cultivation at that time. We assumed that this land, like the forest plot, had been green moss-spruce forest until then. The preservation of undecayed woody roots in isolated places indicates the recent presence of a forest. Plowing and cultivation of the soil markedly alter its profile. When the land was plowed to a depth of 27 cm., the podzolic horizon, morphologically well defined in forest soil, either completely disappeared or was so masked by mixing with the sod horizon that we observed only its traces in the form of small podzolic patches. The plow layer, reaching a depth of 25 to 27 cm., acquired the appearance of the sod horizon; it was colored by humus and had a cloddy, though very unstable, structure. The soils of the plowed tract were described as cultivated, medium humic sod-podzolic varieties with indications, in varying degree, of a residual podzolic character. The following is a morphological characterization of such a cultivated soil:

Horizon A_{plow} 0–27 cm. Dark-brown clay loam, gray when dried; cloddy, unstable structure.

Horizon A_2/B 27–38 cm. Heterogeneously colored, rather compact and structureless clay loam, ocherous with small whitish patches.

Horizon C 38–120 cm. Homogeneous, cinnamon-brown fine clay with scattered grayish-blue gleyed patches; very compact, plastic, effervescing below 75 cm. The quantity of carbonate inclusions markedly increases below 90 cm.

Tables 1 and 2 present the results of both a total analysis and analysis of the contents of the clay and colloidal fractions in samples of forest soils and two sections of plowed soils.

The distribution of clay and colloidal fractions over the forest soil profile shows that the upper part of the profile, particularly down to 14 cm. has a lower content of both these fractions. Below 14 cm., the quantity of colloids and clay fraction gradually increases. At a depth of 38 cm. the clay loam changes to fine clay in which the clay fraction reaches almost 80%, the colloid fraction, 55.6%. As appears from the field description of the soil, below 80 cm. the clay becomes clay loam, indicating the decreased clay fraction and colloid content. The clay fraction and colloid content in the samples from various depths of clay loam under the clay varies within rather wide limits, indicating the heterogeneity of this deposit. The multiplicity of deposits on which the soil was formed makes it difficult to decide to what extent the texture of the soil was affected by the podzolization process. Nevertheless, the coarsening of the texture of the upper part of the soil profile is undoubtedly related not only to the change in deposits but also to the podzolization process.

A total analysis of the forest soil shows that soil podzolization under forest leads to a reduction in the A_1/A_2 and A_2/B horizons of the content of ferric, aluminum, calcium and magnesium oxides and of phosphorus compounds, and to an enrichment in silicate. In the organic horizon A_0 an accumulation of mineral elements occurs with a very pronounced biological accumulation of calcium and phosphorus.

The alteration of total composition at lower horizons is associated with the change in composition of the deposits. A narrow ratio of $SiO_2:R_2O_3$ (3.45) and a low content of calcium silicate (0.18%) are characteristic of the deposition here of fine clay. According to these indices the clay approaches the composition of the colloids (8) extracted from the illuvial soil horizon formed in clay belts and stony clay loams of the Lisinski Teaching Lumber Farm. The clay loam lying under the clay is marked by a high content of total phosphorus (about 0.2%).

The data from the analysis of the field tract (sections 1151 and 1107) show that tillage and cultivation of crops obliterates that differentiation of the upper horizons—with respect to the texture and total chemical composition—which was produced during soil podzolization. On the basis of these indications the upper horizons of cultivated soils approach the average composition of horizons of original forest soil affected by cultivation. From the analysis it is apparent that the cultivation of soils results also in an increase in total calcium and phosphorus content in the upper 20 to 30 cm. of soil. It has been pointed out that the thickness of the soil-forming deposits varied widely. This explains the observed differences in total composition of the plowed soils. Thus, if the soil under the forest at a depth of about 40 cm. (where the clay loam changes to clay) contains 80% clay fraction ($SiO_2:R_2O_3 = 3.45$), then in section 1151 the clay fraction content at this depth is only 53% ($SiO_2:R_2O_3 = 5.51$). In section 1107 the clay appears at the relatively superficial depth of 30 cm. and contains 68.8% clay fraction ($SiO_2:R_2O_3 = 4.14$).

Soil cultivation is more clearly manifest in the change of physico-chemical properties of the soil. The data presented in Table 2 show that the soil under a forest is quite acid. The A_0 horizon has the most acid reaction. For this horizon the pH of the water extract is 3.69, that of the salt extract, 2.9. Podzolized horizons (samples from depths of 7 to 14, 16 to 24 and 27 to 35 cm.) also have an acid reaction; the pH of the water suspension is less than 5, of the salt suspension around 3.5. The clay lying under the upper clay loamy soil horizons also has an acid reaction (the pH of a water suspension of clay is 5.08, that of a salt suspension, 3.76), and only the carbonate clay loam under the clay acquires an alkaline reaction.

As the determination of adsorbed aluminum and hydrogen (performed by the A. V. Sokolov method) shows, the acidity of both organic and mineral soil horizons is caused by adsorbed aluminum and, to a very small degree, by hydrogen.

The determinations of water and salt pH and of exchangeable aluminum and hydrogen in the soils of the field tract showed that the soil reaction in the plow layer rose to pH 6.0 to 5.7 in a water suspension and 5.51 to 4.88 in a salt suspension. However, under the plow layer the reaction remained almost unchanged. The ad-

TABLE 1

Data from the total analysis of soils on the experimental plots

Section No.	Depth of sample, cm.	Hygroscopic water, %	Loss on ignition, %	Humus, %	Bound water, %	SiO_2	TiO_2	R_2O_3	Fe_2O_3	Al_2O_3	P_2O_5	MnO	CaO	MgO	CO
						As percent of ignited weight									
1109 (forest)	0–7	not determined	54.74	not determined		84.72	not determined	10.17	2.23	7.94	0.186	not determined	0.73	0.58	non
	7–14	1.76	5.10	3.45	1.65	86.76	0.48	10.63	1.72	8.45	0.055	traces	0.27	0.33	nor
	16–24	2.39	4.07	1.42	2.65	81.11	0.46	15.48	4.58	10.44	0.052	"	0.27	0.69	nor
	25–35	4.30	5.46	0.51	4.95	76.39	0.45	19.61	5.62	13.54	0.047	"	0.52	1.30	nor
	45–55	8.20	6.39	0.51	5.88	59.30	0.63	32.71	9.48	22.60	0.076	0.05	0.92	2.68	nor
	85–95	3.58	6.66	0.24	6.42	73.15	0.47	18.61	5.50	12.64	0.178	0.04	4.41	2.14	2.5
	115–120	2.61	6.53	0.25	6.28	71.61	0.47	17.68	4.98	12.23	0.160	0.04	5.21	1.92	3.21
	140–150	4.33	7.35	0.40	6.95	64.04	0.35	23.29	6.86	16.18	0.145	0.06	5.09	2.25	3.4
1151 (plowed)	0–10	1.94	6.08	3.48	2.60	83.76	0.30	12.84	3.01	9.53	0.069	0.01	0.54	0.80	
	10–17	2.34	4.53	3.27	1.26	83.64	0.42	13.00	2.63	9.95	0.072	0.02	0.54	0.73	
	20–27	2.47	3.21	1.02	2.19	81.65	0.41	16.05	4.36	11.28	0.025	0.02	0.53	0.82	
	27–35	2.98	3.59	0.61	2.98	79.94	0.52	17.50	5.56	11.42	0.048	0.05	0.37	1.08	
	45–55	4.77	4.43	0.40	4.03	68.93	0.43	24.98	7.39	17.16	0.045	0.06	0.57	1.81	
	100–110	4.68	17.09	0.41	16.68	53.61	not determined	30.54	9.54	21.11	0.154	not determined	9.12	3.45	
1107 (plowed)	0–10	2.06	4.70	not determined		80.77	0.68	14.21	3.56	10.07	0.09	0.02	0.86	0.99	
	10–20	2.38	4.22	"	"	80.20	0.68	14.76	3.54	10.54	0.10	0.02	0.87	1.08	
	30–40	5.08	6.20	"	"	62.43	0.89	29.74	8.66	20.19	0.21	0.04	1.02	2.70	
	80–90	1.90	10.50	"	"	63.43	0.79	21.14	5.94	14.41	0.21	0.03	9.26	2.78	
	108–112	2.66	11.18	"	"	58.98	0.81	24.23	6.77	16.65	0.29	0.03	10.41	2.80	

TABLE 2

Composition of adsorbed cations, pH and contents of clay and colloid fractions in soils on the experimental plots

Section No.	Sample depth, cm.	Me. per 100 gm. of soil				Total	pH		Hydrolytic acidity	v	% particles	
		Ca	Mg	H	Al		H_2O	KCl			<0.001 mm.	<0.0002 mm.
1109	0–7	26.8	5.2	1.23	5.42	38.65	3.69	2.90	—	82.8	—	—
	7–14	0.5	0.57	0.47	5.17	6.71	4.35	3.57	13.21	16.0	14.63	12.30
	16–24	0.65	0.76	0.19	5.22	6.82	4.82	3.55	11.87	20.7	23.58	13.69
	25–35	5.3	4.27	0.15	5.66	15.38	4.70	3.44	11.52	68.8	39.05	28.34
	45–55	23.0	6.49	0.62	0.70	30.81	5.08	3.76	4.98	95.7	79.99	55.64
	85–95	carbonates		none	none		8.19	7.05	none	100.0	30.41	18.92
	115–120	carbonates		none	none		8.27	7.26	none	100.0	27.32	15.32
	140–150	carbonates		none	none		8.25	7.15	none	100.0	50.43	31.35
1151	0–10	7.5	1.31	0.06	0.06	8.93	6.00	4.88	4.07	98.7	23.73	15.99
	10–17	7.0	1.20	0.08	0.40	8.68	5.72	5.51	4.85	94.5	22.54	15.64
	20–27	3.5	1.17	0.09	1.22	5.98	5.08	3.92	5.26	78.0	25.47	18.32
	27–35	6.5	1.97	0.09	2.06	10.62	4.95	3.76	6.13	80.0	31.29	24.74
	45–55	16.0	3.71	0.09	0.89	20.69	5.30	3.96	3.61	95.4	53.20	35.80
	110–120	23.75	5.67	none		29.42	8.04	7.05	0.37	100.0	84.94	53.70
1107	0–10	not determined					6.28	5.20	2.61	not determined	24.65	not determined
	10–20	"		"			6.24	5.02	2.50	" "	24.71	" "
	30–40	"		"			6.43	5.00	2.01	" "	68.75	" "
	50–60	"		"			—	—	—	" "	78.84	" "
	80–90	"		"			7.81	6.71	none	" "	50.04	" "
	108–112	"		"			8.17	7.40	"	" "	63.35	" "

sorbed aluminum content in the plow layer was sharply reduced; in the layer beneath a fairly high content was maintained (2.06 me.; degree of saturation, 80%). The plowed soil of section 1107 had a less acid reaction. Here also the pH of the water suspension from the horizon underlying the plow layers reached 6.43, that of the soil suspension, 5.0; this was obviously related to the increased deposition of clay and, as a consequence, to less original podzolization of the soil.

In forest soil there is considerable accumulation in the litter of calcium and magnesium in an exchangeable form, and a sharp decrease in the content of adsorbed calcium and magnesium of the podzolized horizons, which have a rather high content of adsorbed aluminum. The adsorption capacity in the forest litter horizon reached 38.7 me., and in the A_1 and A_1/A_2 horizons the adsorption capacity was 6.7 to 6.8 me. The degree of saturation in the podzolized horizons reached 16 to 20% altogether.

In cultivated soils the content of adsorbed calcium and magnesium in the plow layer was equalized; however, the adsorption capacity in the plow layer remained low, from 8.7 to 8.9 me. in all, and the degree of saturation increased to 95 to 99%.

The observed analytical data indicate that the cultivation of forest sod-podzolic clay loams leads to an equalization of the texture and total composition of the plow layer of the soil profile, to an alkalization of the soil reaction, and to an increased degree of base saturation.

A study of soil solutions was carried out in the summer of 1950. Soil solutions were extracted from naturally moist samples immediately after they had been taken, using Kryukov apparatus (6) with an oil-extraction press and maximum pressure of 150 to 170 kg./cm.^{2}. The extraction of the solutions was carried out without the use of alcohol, since experiment has shown the impossibility of using alcohol in work with fine-textured clay soils. Since the soils were not always moist enough, the soil solution was not always successfully extracted; in a number of cases the quantity was so small that we were not able to carry out the entire cycle of determinations which had been planned. Since the extracted soil solution in most cases was strongly opalescent, the solutions were subjected to filtration through membrane ultrafilters before all of the analysis except pH and bicarbonate determinations.

In the soil solutions the following determinations were made: pH, electrometrically with a glass electrode; humus content by I. V. Tyurin's modification of the volumetric method; HCO_3 by microtitration with 0.02 N HCl; calcium by Vender's volumetric method. The remaining elements were determined colorimetrically; NO_3 by the Granval-Lyazh method with phenol-2,4-disulfonic acid; NH_3 with Nessler reagent; phosphorus according to Truog's method; silica by A. A. Rode's modification of the Isaac's method; trivalent iron by the alkaline modification of the sulfosalicylic method; divalent iron by α,α'-bipyridyl (according to Kazarinova-Oknina).

Samples for the extracting soil solutions in the forest plot were taken in May and September; in the plowed plot, in May, August and September, 1950.

The pH of the soil solutions from litter, accumulative and podzolic horizons of forest soil lies between 4.46 and 4.56; the pH of the A_2/B and B horizon solutions rises to 6.5; the pH of the soil solutions is somewhat higher than the pH of the water suspensions of the same soil samples. The opposite is observed for carbonate horizons, which have an alkaline reaction in the water suspension. The pH values for the soil solutions of the plow layer of cultivated soils approach neutrality and are also more alkaline than the pH for water suspensions. It is interesting that while nitrification is being carried on at a high rate, in spite of the formation of nitric acid, acidification of the soil solution is not observed, possibly because the nitric acid is immediately neutralized by calcium. The pH of the solutions of both forest and cultivated soil changed little during the time of observation.

Soluble organic matter is one of the main components of the soil solution. According to the data obtained by Trofimov (12) and Skrynnikova (9), the organic matter predominates over the mineral residue in solutions of sod-podzolic soils. Abramova (1) and Skrynnikova (9), on the basis of some indirect considerations, surmised that water-soluble humus of sod-podzolic soils consisted principally of a mixture of various weak organic acids and their salts with strong bases. Such a composition of water-soluble organic compounds determines the reaction of the soil solution. The ability of a group of elements (aluminum, iron, manganese) to combine with many organic acids to produce soluble complex compounds makes possible the presence of these elements in the soil solution. The mineralization of soluble organic compounds is also one of the sources of enrichment of the soil solution by calcium, magnesium, potassium and other elements. Because of the scanty amount of extracted soil solution, it was possible to determine the organic matter in it only for the upper, humified soil horizons, since the content of organic matter fell off sharply with depth, and its concentration fell below the sensitivity limits of the method used. Table 3 shows that in soil solutions from accumulative horizons of forest soil, and particularly in solutions extracted from the A_0 horizon, soluble organic matter is the main component, and its quantity markedly exceeds the sum of mineral matter contained in the soil solution. However, from a comparison of our data with that obtained by Skrynnikova (9), obtained for soils from beneath spruce stand of Moscow region, it is clear that the soil solutions which we investigated differ both in the generally smaller concentration of dissolved matter and in the considerably lower concentration of organic matter. Thus, according to Skrynnikova's figures, the content of organic matter in soil solutions extracted from forest litter reached 3.0 to 3.3 gm. per liter, changing 10 to 15 times in the course of time; from horizon A_1, 624 to 28.8 mg. per liter. For the spruce stand of our investigations the maximum concentration of organic matter in the soil solution from forest litter was 238 mg. per liter and 125 mg. per liter for horizon A_1. These differences may be explained by the higher rate of mineralization of organic matter under conditions of the Kaliningrad region (2) and the higher rate of leaching of the soil. If what Skrynnikova and Abramova established was a considerable rate of change in the content of organic matter in soil solutions and water extracts from their forest soils, then the content of organic matter in our forest plot soil solutions proved to be extremly stable during the observation period (May to September). Thus, in the A_0 horizon soil solution in May the humus content was 238.3, in August 255.9 and in September 219.6 mg. per liter; in that from horizon A_1 in May it was 124.3 and in September 120.3 mg. per liter.

The content of organic matter in soil solutions from the plowed plot during the entire period of observation was considerably lower than in forest soil. Horion A_1 of forest soil and the plow layer of cultivated soil contained similar quantities of total humus (3.45 and 3.48%). However, if the concentration of organic matter in the A horizon soil solution of forest soil is 120 mg., th maximum concentration of organic matter i the soil solution of the cultivated soil's plow layer is 70 mg.; this indicates a considerable decrease in solubility of organic matter in cultivated soil. Similar data were obtained by Blagovidov (3) who showed that the quantity of water-soluble organic matter in plowed soi decreased by 25 to 40% in comparison with virgin soil. Garkusha (4) related the decrease mobility of organic matter after soil cultivation with the relative decrease of fulvic acids in the humus content of these soils.

A gradual decrease in the organic matter content from spring to fall was observed in the plowed soils. While the soil solution of forest soil contained more organic matter than mineral residue, plowed soil contains less organic than mineral matter particularly in spring when the soil solution is most mineralized. The organic matter of soil solutions of forest and plowed soil may also differ qualitatively, but the absence of appropriate methods prevents a study of the qualitative composition of organic matter in soil solutions.

The high degree of mineralization of the soil solution of cultivated soil at the spring sampling was caused by the high rate of nitrification at this time and by accumulation of a large quantity of nitrates. Nitrates were not found in the soil of the forest plot at any of the observation dates, either in the soil horizons or in the litter. This is not surprising, since many Russian and foreign investigators have noted the suppression of processes of nitrification in coniferous forests (7, 11, 13). In the soils of the plowed plot the nitrate content at various sampling dates varied very widely. In spring, when the vegetation was still quite undeveloped, nitrates were the main component of the soil solution. With the development of vegetation, the nitrate content in the soil solution fell sharply, remaining at a low level also in autumn after harvesting. A comparison of the cation and anion fractions of the soil solution shows that the nitrates are found in the soil solution in the form of calcium salts, since there is a decrease in calcium concentration parallel to the decrease in nitrate concentration in the soil solution.

The absence of the nitrification process in forest soils and its vigorous development in the

TABLE 3

Composition of soil solutions from soils of experimental plots

Plot	Date	Depth of sample, cm	Horizon	pH	Organic matter, mg. per liter	Ca	Mg	Fe^{++}	Fe^{+++}	NH_4	HCO_3	NO_3	SiO_2	Ca	Mg	Fe^{++}	Fe^{+++}	NH_4	HCO_3	NO_3	SiO_2
						In me. per liter of soil solution								In mg. per liter of soil solution							
Forest	May, 1950	0–7	A_0	4.46	238.3	1.02	0.66	0.67	1.14	stained	0.72	none	1.39	20.4	7.92	20.0	25.0	stained	43.9	none	41.82
		10–14	A_1	4.46	124.3	0.62	0.32	0.28	0.7	0.34	0.2	traces	0.82	12.4	3.84	8.0	14.0	6.12	12.2	none	24.53
		14–20	A_2	4.56	72.5	0.46	0.34	0.10	traces	0.44	0.2	none	0.74	9.2	4.08	3.0	traces	8.0	12.2	none	22.30
		25–30	A_2/B	6.50	41.5	0.25	1.40		traces	0.23	0.2	none	0.75	5.0	16.8	none	traces	7.25	12.2	none	22.58
		35–42	B	6.50	n.d.	0.40	1.81	none	none	0.43	0.4	none	0.82	0.4	21.8	none	none	7.75	24.4	none	24.53
		105–115	D_1	7.78	36.3	4.1	1.60	none	none	0.50	3.0	none	0.611	82.0	19.2	none	none	8.75	183.0	none	18.40
Forest	Sept., 1950	0–7	A_0	4.77	219.6	1.23	—	0.5	1.40	stained	2.74	none	0.43	24.6	—	14.0	25.0	stained	167.1	none	12.9
		10–14	A_1	4.56	120.3	1.95	—	0.3	0.806	0.20	n.d.	none	0.74	39.0	—	8.4	15.0	3.60	n.d.	none	22.3
		14–20	A_2	n.d.	n.d.	—	—	none	none	0.32	n.d.	none	n.d.	—	—	none	none	5.76	n.d.	none	n.d.
		25–30	A_2/B	n.d.	n.d.	—	—	none	none	0.15	n.d.	none	n.d.	—	—	none	none	2.70	n.d.	none	n.d.
		35–42	B	6.80	n.d.	0.46	—	none	none	0.50	2.3	none	0.309	9.2	—	none	none	9.00	140.3	none	9.27
		105–115	D_1	7.50	n.d.	1.3		none	none	0.50	0.6	none	0.868	26.0	—	none	none	9.00	36.6	none	26.0
Plowed	May, 1950	0–10	A_{plow}	6.86	75.1	5.62	1.78	none	none	0.24	1.60	none	0.746	112.4	21.36	none	none	4.32	97.6	none	22.4
		32–42	B	6.81	—	0.78	2.60	none	none	0.145	0.40	4.44	0.501	15.6	31.20	none	none	2.61	24.4	275.3	15.0
		120–130	D_1	n.d.		3.80	1.1	none	none	0.05	0.60	0.62	0.278	76.0	13.2	none	none	0.90	36.6	38.44	8.34
Plowed	Aug., 1950	0–10	A_{plow}	6.99	67.5	1.02	n.d.	none	none	0.138	0.27	0.08	0.536	20.4	n.d.	none	none	2.48	16.5	4.96	16.08
		32–42	B	5.65		1.48	n.d.	none	none	0.083	0.45	none	0.526	29.6	n.d.	none	none	1.49	27.45	none	17.78
		120–130	D_1	6.61		4.07	n.d.	none	none	0.05	3.20	none	0.519	81.4	n.d.	none	none	0.90	195.2	none	15.57
Plowed	Sept., 1950	0–10	A_{plow}	6.29	57.1	1.50	1.05	none	none	0.05	0.48	0.08	0.296	30.0	12.6	none	none	0.90	29.28	4.96	8.88
		32–42	B	5.76		n.d.		none	none	n.d.		none		n.d.		none	none	n.d.		none	n.d.
		120–130	D_1	8.04		1.50	2.00	none	none	0.05	2.00	none	0.291	40.0	18.0	none	none	0.9	122.0	none	8.73

n.d. = not determined.

plowed soil plot is one of the signs of substantial differences in their activity.

Although we found nitrates only in the plowed soil, nitrogen in ammonia form occurs in both forest and cultivated soil solutions. It must be pointed out that the ammonia concentration in soil solutions of the forest soil we investigated was much lower than the ammonia concentration found by Skrynnikova in soil solutions from Moscow region spruce stands. She surmised that ammonia existed in the soil solutions mainly in the form of ammonium salts of organic acids. Since in the soil solutions from our forest plot we discovered a considerably lower concentration of organic matter than was found in soil solutions of Moscow region spruce stands, it is natural to suppose that the ammonia concentration of soil solutions from our spruce stand is also lower. Ammonia percolates deeply into the soil, and we found it, although in insignificant quantities, in soil solutions extracted from soil samples taken at a depth of one meter. The ammonia concentration in forest plot soil solutions at different sampling dates is fairly constant.

The ammonia content in soil solutions from plowed soils is somewhat smaller than that from forest soil, especially in the deeper horizons. Toward fall it decreases somewhat, but not to such a degree as does the nitrate content.

Attempts were made to determine the phosphoric acid content of soil solutions by Truog's colorimetric method; however it was not found even once. The literature also cites the very low concentration of phosphorus in soil solutions. The soils we investigated have the property, as shown by special experiments, of rapidly fixing applied phosphates, transforming them into forms insoluble in water.

The silicate content was also determined from the anions in the soil solutions. This varied widely in different soils and at various sampling dates. The highest SiO_2 content in the soil solutions was found in the forest plot soil in spring, especially in the forest litter horizon. Towards fall the SiO_2 content decreased. In the cultivated soil solutions the SiO_2 content is lower than in the forest soil solutions; it is highest in the plow layer and falls off in the lower soil horizons. In plowed soil solutions the SiO_2 content also increases in spring and is lowered in fall. The difference between the SiO_2 content of forest and plowed soil solutions may be explained by the accumulation of SiO_2 by forest vegetation.

Among cations found in both forest and plowed soil solutions, calcium holds first place constituting on the average about 30 to 40% of the mineral residue. These figures agree well with the results of research by Skrynnikova who found a direct dependence between the electrical conductance of soil solutions and their calcium content. The calcium content in soil solutions of both soils is clearly differentiated by horizons. In forest plot soil, the maximum concentration and maximum content of calcium (with the exception, of course, of the carbonate horizon), occurs in the layer of forest litter and in horizon A_1/A_2; deeper, the calcium concentration falls off, reaching its minimum in horizon A_2/B and again increasing in the carbonate horizon. The high calcium content in the litter and in horizon A_1/A_2 is related to its passage into solution in the form of calcium bicarbonate following mineralization of the organic matter. The calcium concentration in the soil solution of the carbonate horizon. is determined by the passage of this cation into solution in the form of calcium bicarbonate.

In the plow layer of soil the calcium concentration is especially large at the spring sampling time; this is related to the process of nitrification. There are a number of citations in the literature (12, 10, 5) of the interdependence of the nitrification process and the transfer of calcium into the soil solution. In summer and fall, when the nitrate content of the soil solution decreases, the calcium concentration also decreases. At this time only the calcium which is combined with bicarbonates remains in the soil solution. As in forest soil, the calcium concentration increases abruptly in the carbonate horizon.

Soil solutions from forest and plowed soil plots as a rule differ regularly in content of di- and trivalent iron. As is apparent from the data in Table 3, soil solutions from the upper horizons of forest soil always contain divalent iron. Trivalent iron was detected in them only after oxidation of organic matter; from this it follows that trivalent iron is present in forest soil solutions in combination with organic matter. In the soil solution extracted from samples of plowed soil, divalent iron was not found at any sampling time.

Conclusions

1. In this paper we report the results of a comparative investigation of the properties of

sod-podzolic soils of Kaliningrad region under spruce forest and cultivated land.

2. Cultivated sod-podzolic soils differ from forest sod-podzolic soils in:

a) Less differentiation of soil profile by morphological features;

b) Homogeneity of the plow layer of the profile in both total composition and texture.

3. Soil solutions of cultivated and forest soils differ in composition and degree of mineralization.

4. Forest soil solutions were characterized by considerable difference in composition along the profile and by comparatively small variability during the period of observation. The composition of cultivated soil solutions is more homogeneous in the upper part of the soil profile but varies more with time.

5. Organic matter was the main component of the soil solutions of forests litter and the accumulative horizon of forest soil during the entire period of observation. In soil solutions from the upper horizons of forest soil, organic matter predominates over mineral residue.

The content of organic matter in cultivated soil solutions is lower than in those from forest soil, and the mineral residue in the cultivated soil solutions predominates over organic matter.

6. The degree of mineralization of cultivated soil solutions is especially high in spring, as a consequence of the high rate of nitrification and the accumulation in the soil solutions of calcium nitrate. Nitrates are not found in the forest soil solutions.

7. The soil solutions from accumulative horizons of forest soil, in spite of their high biological accumulation of calcium, like the soil solutions from the podzolized horizons of this soil, have an acid reaction which is caused by the presence of organic acids.

The reaction of the soil solution from the plow and subsoil horizons of cultivated soil approaches neutrality. The reaction of soil solutions changed insignificantly during the period of observation.

8. In both forest and cultivated soil solutions no phosphoric acid was found.

9. The constant presence in forest soil solutions of divalent iron is an important distinguishing sign of soil formation under a forest. In soil solutions of cultivated soils, divalent iron is absent.

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SOME PROPERTIES OF TAKYRS ON THE KIZYL-ARVAT PLAIN, SOUTHWESTERN TURKMENISTAN

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A FAIRLY large body of literature has been devoted to the processes of takyr formation in the desert regions of Central Asia. A complete bibliography on this may be found in he monograph "Takyrs of Western Turkmenistan and methods for their agricultural reclamaion," Izdatel'stvo Akad. Nauk SSSR, 1956. Of special interest is the possibility that takyrs may be solodized at a certain stage of their development.

The first to refer to the solodization of takyrs was Paletskaya (18). However, her conclusions were based exclusively on distribution of the extural fractions in layers. Bolyshev (6, 7), on he basis of a large amount of data from abridged omplete analyses of takyrs, also came to the onclusion that takyr formation is accompanied by solodization in the uppermost layer. But unike Paletskaya, who considers solodization from he point of view of the physicochemical concepts of Gedroits (8), Bolyshev believes that olodization is caused by the life processes of algae. The algae act directly on minerals and destroy the aluminosilicates with the formation of the simple compounds SiO_2, Al_2O_3 and Fe_2O_3.

A tendency for mineral compounds to transocate in the superficial horizons is evidence of solodization as observed in the takyrs of the ancient deltas of the Tedzhen and Murgab rivers (17). Solodization of takyrs is confirmed by a number of such data. However, these data are essentially of an indirect nature.

Bazilevich (20), on the basis of a detailed investigation of the complete composition of takyrs, and also of the data of Gorbunov, Labenets and Sharina (13) on the exchange capacity of the fraction <0.001 mm. diameter—its complete composition, dehydration curves and so forth—confirmed and provided evidence of the occurrence of solodization in takyrs. Feofarova's microscopic examinations (24) also provided evidence of the development of solodization in takyr crusts. Uspanov's data (23) on the exchange capacity of the colloidal fraction of different takyr horizons showed a decrease in the exchange capacity of the crust as compared with horizons below it. This phenomenon may also be related to solodization, but Uspanox did not explain it.

In order to further clarify solodization occurring in takyrs we investigated changes in salt relations and—the most active part of the soil—the colloids (particle diameters $<0.3\mu$) since, primarily, soil-forming processes should be reflected in changes in the most mobile part of the soil.

One of the major factors in solonetz formation and solodization of takyrs is a fairly active exchange of salts. This exchange is associated with the unusually sharp variability of the water relations of the soil. A number of authors have referred to this (3, 9, 10, 11, 12, 17, 18, 19, 25). Such data are also given by P. I. Shavrygin in the monograph on takyrs (20). Takyrs are known to be subject to two sharply different periods in the annual cycle: a very brief moist period and a prolonged dry one.

The data given in Table 1 show considerable differences in both qualitative and quantitative composition of salts in spring and summer. During the moist period there is a characteristic leaching of salts in the takyr profile down to a depth of 10 to 15 cm., increased alkalinity, and (in the upper horizons) a preponderance of carbonate-bicarbonate salts, generally those of the alkali metals. Desalinization in the spring is replaced by salinization in the summer. Salts leached from the upper horizons migrate to the surface with the capillary moisture. During this period there is a sharp increase in the total salts, especially in the chloride content; the alkalinity drops to negligible values and the carbonate-bicarbonate type of salt content is replaced by the chloride type. The appearance of $MgCl_2$ and $CaCl_2$ in the soil solution is evidence of the exchange reaction between NaCl and the adsorbing complex, which is saturated chiefly by calcium.

The annual rhythm and recurrence of desalinization and salinization, preponderance of NaCl in the salt composition, and almost complete absence of $CaSO_4$ in the upper horizons are all factors favoring the development of phenomena resembling solonetz formation in takyrs—but

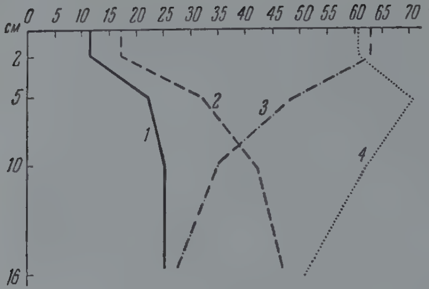

FIG. 1.—Content of physical sand (>0.01 mm.), fine clay (<1μ) and colloids (<0.3μ) in a takyr (as percent of humus-, carbonate-, salt- and gypsum-free oven-dry sample). 1—Fraction <0.3μ; 2—fraction <1μ; 3—fraction >0.01 mm.; 4—percent of colloids in the fine clay fraction.

only down to a depth to which the migration of salts extend. The solonetz-forming action of NaCl is intensified, since these phenomena evolve against a background of carbonates (14). It is characteristic that these processes of salt exchange in takyrs take place only down to a depth of 18 to 20 cm., that is, in the horizon which becomes moistened. Below this, no material changes in the salt composition of the soils were noted. Morphological manifestations of t solonetz formation agreed completely with t data from the textural and chemical analys Solonization in takyrs is accompanied by solo zation phenomena.

The distribution of fine fractions along t profile of the takyr reflects clearly the migrati of colloids and the formation of horizons simil to the eluvial and illuvial horizons of solodiz solonetzes. However, inasmuch as the takyrs the Kizyl-Arbat plain are surrounded by lar bodies of sands, this view may be questione Differentiation of the texture of the profile ma occur as a result not of the soil-forming proce but of the heaping up of sand on the surface. T rule out the possibility of such an objection, v recalculated the yield of colloids in percentag of the clay fraction. According to these data w are fully justified in inferring that colloids m grate within the soil—that solodization take place.

Solodization causes substantial changes in th organic and mineral portions of the colloids o takyrs (Table 2). The humus content of th takyr colloids at the most superficial part of th crust reaches 13%, that is, almost thirteen time

TABLE 1

Dynamics of the quantitative and qualitative composition of salts in takyrs (profile 266)

Depth, cm.	As percent of dry weight				As percent of total milliequivalents of salts[a]									
	Solid residue	Cl	Alkalinity		Na_2CO_3	$Ca(HCO_3)_2$	$Mg(HCO_3)_2$	$NaHCO_3$	$CaSO_4$	$MgSO_4$	Na_2SO_4	NaCl	$MgCl_2$	$CaCl_2$
			CO_3	HCO_3										
							Spring							
0–2	0.20	0.02	0.002	0.06	3.0	7.5	24.5	17.0	none	none	20.0	28.0	none	none
2–5	0.32	0.03	0.01	0.16	11.0	5.0	8.0	34.0	“	“	14.0	28.0	“	“
5–10	0.37	0.12	0.01	0.085	7.0	4.0	8.5	6.5	“	“	7.0	68.0	“	“
10–18	0.67	0.36	none	0.033	none	1.8	2.7	none	“	1.5	4.0	90.0	“	“
18–35	2.2	0.60	“	0.015	“	7.0	none	“	34.0	3.5	1.5	54.0	“	“
35–56	2.4	0.72	“	0.011	“	4.0	“	“	45.0	1.0	none	41.0	“	“
56–66	1.8	0.48	“	0.011	“	6.0	“	“	40.0	6.0	“	44.0	“	“
							Summer							
0–2	0.40	0.24	none	0.034	none	6.3	none	none	1.7	none	none	90.0	none	2.0
2–5	0.80	0.52	“	0.023	“	4.0	“	“	3.0	“	“	82.0	3.0	8.0
5–10	0.90	0.58	“	0.023	“	2.5	“	“	1.5	“	“	92.0	2.5	1.5
10–18	1.60	0.76	“	0.013	“	1.0	“	“	26.0	“	“	62.0	9.0	2.0
18–35	2.10	1.11	“	0.013	“	0.5	“	“	18.5	“	“	61.0	10.0	10.0
35–56	1.9	0.85	“	0.011	“	1.0	“	“	29.0	13.10	“	34.0	none	23.0
56–66	1.8	0.56	“	0.011	“	6.0	“	“	35.0	none	“	49.0	“	none

[a] The salts were calculated on the basis of data from the water extract by combining the ions int salts in relation to their solubilities.

TABLE 2

Total composition and exchange capacity of takyr colloids

Depth, cm.	Exchange cap'y me./100 gm. soil	As % of oven-dry wt.			As percent of ignited sample of colloids												Total without water of hydration	$\frac{SiO_2}{Al_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$
		Humus	Hygroscopic water	Chemically bound water	SiO_2	R_2O_3	Al_2O_3	Fe_2O_3	P_2O_5	CaO	MgO	SO_3	Na_2O	K_2O	TiO_2	MnO_2			
0–2	49.32	12.91	5.94	11.08	59.04	29.07	10.41	18.66	0.21	2.07	1.99	2.64	1.0	4.41	0.79	traces	101.23	9.24	8.44
2–5	53.52	4.0	5.87	8.02	58.13	35.31	18.62	16.69	0.16	1.72	2.93	1.45	0.23	4.82	0.68	"	100.99	5.30	9.27
5–10	55.17	3.11	4.85	4.50	58.67	31.88	23.45	8.43	0.13	0.40	3.78	0.82	0.80	3.83	n.d.		100.31	4.25	18.6
10–18	57.51	1.76	7.28	7.21	59.57	32.54	24.13	8.41	0.18	0.23	4.11	0.53	0.68	4.07	"	n.d.	101.91	4.19	18.9
Total composition of colloids as percent of original soil																			
0–2		1.1			4.82	2.37	0.85	1.52	0.02	0.17	0.18	0.21	0.08	0.36	0.08	traces			
2–5		0.80			10.92	6.63	3.50	3.13	0.03	0.32	0.55	0.25	0.04	0.90	0.15	"			
5–10		0.75			13.72	7.45	5.48	1.97	0.03	0.08	0.88	0.19	0.02	0.90	n.d.	n.d.			
10–18		0.43			13.00	7.09	5.26	1.83	0.04	0.05	0.89	0.11	0.014	0.88	"	"			
Total composition of colloids as percent of total composition of original soil																			
0–2		98.1			6.82	12.4	5.77	34.5	12.0	11.6	9.0	—	4.0	15.0	12.5	traces			
2–5		100.0			15.78	32.0	22.6	60.3	15.0	24.8	25.0	—	2.2	35.0	22.4	"			
5–10		100.0			19.87	34.8	33.1	41.0	30.3	7.2	50.0	—	—	—	n.d.	n.d.			
10–18		100.0			18.37	35.5	34.7	38.1	35.0	4.4	45.3	—	1.3	34.0	"	"			

as much as in the same horizon of the original soil. Deeper in the profile the humus content of the colloids falls to 1.76 to 4%. This sharp decrease in humus content from the upper horizon and to the lower ones is due to the fact that the crust, which is between 0 and 2 cm. thick, contains a 2 to 3 mm. solid film of algae. The algae disappear almost completely at greater depths.

After SiO_2, Al_2O_3 and Fe_2O_3, humus is the fourth most abundant component in the composition of the colloids. It is one of the basic components of the colloidal part of the soil.

Considerable variation was observed along the profile of the takyrs in the mineral composition of the colloids. Takyr profiles are divided into two parts with respect to the distribution of compounds of Al, Fe, P, Ca, Mg, S, K, and Na. Compounds of Fe, P, Ca, Na and K accumulate in the top 5 cm. of soil, chiefly in the 0 to 2 cm. crust. Kovda (16) suggests that the accumulation of these compounds and especially of Fe_2O_3 is one of the characteristics of meadow conditions. Considering that every year takyrs are flooded by surface water and for a certain brief period of time are under the influence of excessive moisture, they pass through a kind of very short meadow stage. This process takes in only the most superficial horizons of the takyr because any deeper penetration of moisture is prevented by the very low permeability. On the other hand there is a minimum content of Al and Mg compounds in the upper horizon which increases with depth. Evidently the processes of solodization and solonetz formation affect primarily the leaching of MgO and Al_2O_3. No characteristic marked accumulation of SiO_2 in the solodized horizon is observed with takyr colloids. The difference in SiO_2 content between the upper and lower horizons is not more than 1%, so that according to these data it is difficult to state whether solodization is present or not.

In the upper horizon the molecular ratio of SiO_2 to Al_2O_3 is very high—9.24. Lower down the ratio decreases abruptly to 5.3 to 4.19—values characteristic of minerals in the montmorillonite group, the presence of which has been established by x-rays. A lower ratio of SiO_2 to Al_2O_3 in the lower horizons is evidence that Al_2O_3 is being leached from the upper part of the profile because Al_2O_3 is more mobile than SiO_2 during solodization. The ratio of SiO_2 to Fe_2O_3 along the takyr profile shows the accumulation of Fe_2O_3 in the upper horizons. The cause of this was explained previously.

On the basis of information about the total composition of the takyr colloids it is still difficult to come to a conclusion about the solodization of takyrs. These data show the similarity of the total composition of the colloids of takyrs to those of the soils of the steppe series. However, if we recalculate the total composition of the colloid fraction of the takyr with respect to the original soil, taking into account the percentage yield of colloids, the essential difference among the genetic horizons of takyrs is very clearly revealed (Table 2). (The method for the calculation was suggested by V. A. Kovda and G. M. Kader [16].) The role of humus in the formation of the illuvial horizon, in which the humus content reaches as much as 0.8%, then becomes quite obvious. The humus can get into the illuvial horizon in such quantities only as a result of leaching. The sharp drop in humus content of the 10 to 18 cm. horizon shows that the illuvial process tapers off here.

Considerable migration of the mineral part of the takyr colloids, too, becomes evident. Al_2O_3 and MgO show the highest rate of accumulation in the illuvial horizons. The content of these in the accumulative horizon is higher than in the upper horizon by 400 to 540%. The intensive migration of MgO is also a result of the developing solodization, as was established by the papers of Bazilevich (2).

A considerably smaller accumulation is characteristic of Fe_2O_3. Its quantity in the illuvial horizon increases by 200% at most. Evidently the iron compounds are biologically fixed in the upper horizon. Not only compounds of Fe, Al and Mg but also SiO_2 become increasingly mobile. The difference in SiO_2 content between the eluvial and illuvial horizons reaches 200 to 250%. This is evidence of the desilication of the minerals in the upper part of the takyr crust and of the liberation of SiO_2. The migration of K and Ca compounds and their accumulation in the illuvial horizon is most probably due to the extreme weakness of the biological processes which fix them, and not to the solodization process.

All the preceding data given clearly show that in takyrs there is fairly intense migration not only of Al, Fe and Mg, but also of SiO_2. However, the ability of these compounds to assume colloidal form is extremely diverse. In solodization, the most mobile is humus. In the upper horizon up to 98% of the humus is in colloidal form. (The calculations were suggested by V. A. Kovda and G. M. Kader [16].) The value of the content in colloidal form of any element (Table 2) is divided by the gross content of the same element in the soil, and expressed as a p centage (that is, multiplied by 100). In the lo horizons the humus is entirely colloidal wh proves its illuvial origin.

Among the mineral components Fe_2O_3 is one with the greatest ability to migrate in c loidal form. In the illuvial horizon up to 60% the total content of Fe_2O_3 is in the mobile sta The MgO is in second place. In the horizon maximum leaching, up to 50% of the total co tent of MgO is converted to the colloidal for The Al_2O_3 is in third place.

In the eluvial horizon, the content of c loidal Fe, Al and Mg is two to three times small as in the illuvial horizon. An extreme small amount of the SiO_2 is colloidal. In t upper horizon only 6.8% of the total SiO_2 in the soil is in colloidal form. The mobile SiO_2 leached into the lower horizons in the proce of desilication. This is shown by an increase the amount of SiO_2 in colloidal form of up 16 to 20% of the total SiO_2 content in the luvial horizons. It is possible that a certain pa of the mobile forms of SiO_2 is formed *in sit* The rather high Ca content in the colloids—u to 24% of the total content of Ca—is not worthy. Evidently Ca compounds also take pa in the formation of secondary minerals in ta kyrs.

Thus, the upper horizons of takyrs show con siderable migration of the mineral and organ components within a 10 to 20 cm. limit. Accord ingly, horizons are formed in takyrs whicl though not thick, are well-differentiated: eluvia in the upper part of the crust and illuvial in th lower. The solodization of the upper part of th takyr crust is also manifested by the change i mineralogical composition in the profile. Th data from x-ray analysis of the colloidal fractio showed that the solodized part of the profil lost hydrophilic clay minerals—beidellite—an acquired some of the more hydrophobic ones— hydromicas. In this connection, the exchang capacity of the takyr colloids is least in th particular horizon (Table 2).

On the basis of the data cited we can set up series showing the degree of participation by th different components in formation of the illuvia horizon:

$$\text{organic matter} > Fe_2O_3 > MgO > K_2O$$

$$= P_2O_5 = Al_2O_3 > CaO > TiO_2 > SiO$$

Comparing this series with the series similarly set up for solonetzes (16) we get:

$$\text{organic matter} > Fe_2O_3 > Al_2O_3 > MgO > CaO > SiO_2 > TiO_2$$

and the series for solodized solonetzes (4) is:

$$\text{organic matter} > Fe_2O_3 > Al_2O_3 > MgO > SiO_2 = MnO > CaO$$

and it is possible to see a great similarity between them.

Thus, without denying specific traits in the formation of takyrs, we are once again convinced of the similarity between takyr formation and solonetz formation.

The question of the intensity of solodization and solonetz-forming processes in takyrs is of interest. On the basis of a great deal of data, Kovda (16) and later Bazilevich (2, 4) came to the conclusion that at different stages of solodization and solonetz formation the mobility of certain elements changes. Thus Kovda (16) states that at the beginning of solonization Mg compounds are leached relatively slowly from the upper horizons and even show some accumulation. In the following stages they undergo considerable leaching. The mobility of MgO as a characteristic sign of solodization was also noted by Bazilevich (2). Further, the mobility of SiO_2 increases in proportion to the degree of solodization, and this increase leads to the formation of a well-defined illuvial horizon in the soils of the solonetz series (15, 16).

We have therefore come to the conclusion that the processes of solonetz formation and solodization in takyrs are in the stage of full development, with sharp differentiation by genetic horizons. However, the thickness of the horizons, and consequently the extent of morphological expression of solodization in takyrs, is extremely small. This is due to the specific conditions of takyr soil formation in which the entire layer of present soil formation is restricted to a thickness of 20 to 25 cm. By analogy with solonetzes, they might be called solodized "dwarf" solonetzes.

TABLE 3

Content of mobile, amorphous SiO_2 in the soils of the Kizyl-Arvat plain as a percentage of a salt-, carbonate-, humus- and gypsum-free oven-dried sample

Profile No.	Depth, cm.	SiO_2	Al_2O_3	$2SiO_2 \cdot Al_2O_3$	Amorphous SiO_2	Mobile Al_2O_3	$\frac{SiO_2}{Al_2O_3}$
388, solonchak	0–1	0.174	0.60	0.31	none	0.46	0.52
	1–8	0.206	0.38	0.60	"	0.20	0.94
	8–12	0.105	0.48	0.19	"	0.38	0.38
336, takyr–solonchak	0–0.5	0.36	0.24	0.45	"	0.58	0.75
	0.5–2.5	0.12	0.23	0.42	"	0.33	0.80
	2.3–8	0.061	0.21	0.37	"	0.28	0.80
266, takyr	0–0.2	0.87	0.39	0.84	0.42	none	4.00
	0.2–2	0.43	0.16	0.35	0.25	"	4.80
	2–5	0.61	0.17	0.35	0.41	"	5.20
	5–10	0.48	0.13	0.29	0.33	"	6.00
	10–18	0.12	0.69	0.22	none	0.58	0.31
	18–35	0.47	0.72	0.89	"	0.30	1.18

One of the characteristic signs of solodization of soils, as pointed out by Gedroits (8), is the presence of amorphous SiO_2 extractable by 5% KOH. However, it was later shown that this SiO_2 may be of biological origin and completely unrelated to the solodization processes (4, 21, 22). Actually, as may be inferred from our data (Table 3), the greatest amount of amorphous SiO_2 is in the algal film, which is some evidence of its biogenic origin. However, purely physicochemical processes of amorphous SiO_2 formation also take place in takyrs when there is a strongly alkaline reaction in the horizons fully saturated with exchangeable sodium (2 to 5 and 5 to 10 cm.), in which the algae are almost completely absent. It is characteristic that the amorphous SiO_2 completely disappears in the 10 to 18 and the 18 to 25 cm. horizons with a decrease in the alkaline reaction.

In soils genetically related to takyrs but in still earlier stages of development, the formation of SiO_2 in mobile form does not occur even in the most superficial horizon. This is because the water-salt relation characteristic of takyrs has not yet been established in which solonetz formation and solodization can develop.

Solonchaks and takyr-solonchaks are essentially in the initial stage of soil formation and consist rather of soil accretions not yet differentiated into horizons. Confirmation for this conclusion may be found in data obtained from soils in different stages of development which have been extracted first by 10% HCl and then treated with 5% KOH (Table 4). Thus, in a solonchak (profile 338) with beginning signs of soil formation, there is no differentiation at all of the content of the mineral components. The distribution of oxides reflects only the diverse compo-

TABLE 4

Data from the analyses of 10% HCl and 5% KOH extracts of different soils of the Kizyl-Arvat plain as a percentage of a salt-, carbonate- and humus-free oven-dried sample

Profile No.	Depth, cm.	10% HCl				5% KOH after HCl		Total of both extracts		$\frac{SiO_2}{R_2O_3}$	$\frac{SiO_2}{Fe_2O_3}$	$\frac{Si}{Al}$
		SiO_2	$R_2O_3 + P_2O_5$	Fe_2O_3	$Al_2O_3 + P_2O_5$	SiO_2	Al_2O_3	SiO_2	Al_2O_3			
338	0–1	0.092	12.82	3.28	9.54	11.64	0.424	11.73	9.96	1.80	10.35	2.
	1–8	0.034	9.75	4.32	5.43	12.31	0.073	12.34	5.50	2.72	8.03	4.
	8–12	0.09	10.57	4.17	6.40	14.22	0.068	14.31	6.47	2.60	9.73	3.
336	0–0.5	0.069	10.28	3.34	6.94	11.35	0.36	11.42	7.30	2.20	9.57	2.
	0.5–2.5	0.13	13.41	5.40	8.01	13.64	0.12	13.73	8.13	2.10	7.20	3.
	2.5–8	0.096	8.81	3.57	5.24	12.15	0.061	12.24	5.30	2.9	9.86	4.
266	0–0.2	0.074	7.18	4.16	3.02	8.90	0.16	8.97	3.18	2.77	5.85	5.
	0.2–2	0.053	8.74	3.82	4.92	8.85	0.12	8.90	5.04	2.15	6.54	3.
	2–5	0.083	13.36	5.10	8.26	12.33	0.15	12.41	8.41	1.80	4.29	2.
	5–10	0.113	12.85	3.77	9.08	14.46	0.16	14.57	9.24	2.26	10.75	2.
	10–18	0.019	11.0	3.48	7.52	15.41	0.13	15.43	7.65	2.81	12.40	3.
	18–35	0.138	9.37	4.47	4.90	13.16	0.15	13.30	5.08	3.05	8.39	4.

sition of the leached material on which the soils of the Kizyl-Arvat piedmont plain are formed.

The later stage, takyr-solonchak (profile 336), is characterized by some tendency for R_2O_3 to migrate and accumulate at some depth. This is shown by the ratio $SiO_2:Al_2O_3$. In comparison with profile 338, profile 336 shows a decrease in the $SiO_2:Al_2O_3$ ratio, and only in takyrs does the distribution of R_2O_3 and SiO_2 indicate significant migration with the formation of an accumulative horizon. The fact that there is some increase in the $SiO_2:Al_2O_3$ and $SiO_2:R_2O_3$ ratios in the upper horizon is not evidence of the accumulation of SiO_2 but rather of the greater mobility of R_2O_3 than of SiO_2 in the solodization process.

Thus, on the Kizyl-Arvat piedmont plain takyr formation is accompanied by solodization developing only at a certain stage and under certain conditions of water-salt relations.

Conclusions

1. Development of the takyrs of the Kizyl-Arvat piedmont plain takes place under conditions of sharply varying water-salt relations.

2. Under the influence of the alternate ascending and descending flow of soil moisture and periodic desalinization and salinization, solonetz formation and solodization develop and steadily increase with time.

3. Solodization in the upper part of the crust is shown by the following signs: a) impoveri ment of colloidal content in the upper part the crust horizon; b) a change in the mineralo cal composition of the colloids resulting in e richment of hydromica content in the solodiz horizon; c) a decrease in the exchange capaci of colloids in the solodized horizon; d) t migration of organic matter and of Fe, Al, M Si and Ca compounds from the upper part of t takyr to the lower part.

As a result of these changes well-marked luvial and eluvial horizons are formed.

4. The extent of participation by mineral co ponents in the formation of the illuvial horiz is expressed by the following decreasing serie

$$\text{organic matter} > Fe_2O_3 > MgO > K_2O$$

$$= P_2O_5 = Al_2O_3 > CaO > TiO_2 > SiC$$

This is similar to the series for solonetzes a solodized solonetzes.

5. Judging by the extent of migration of number of compounds such as MgO, SiO_2 a CaO, it is reasonable to assume that takyrs a not in the initial but in the more mature sta of solodization.

6. The soil-forming profile in takyrs is limit to a thickness of 20 to 25 cm., that is, to t depth to which wetting by atmospheric preci tation takes place.

7. Solodization is characteristic only of takyrs. At earlier stages of soil formation on the Kizyl-Arvat plain solodization does not take place.

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DEVELOPMENT OF GULLIES IN THE OB' REGION

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In the spring and summer of 1950 the author investigated the development of gullies on the Ob' steppe near the town of Barnaul on the west bank of the Ob' river where the growth of gullies was threatening some industrial and civic buildings. The investigation was made to predict the rate of gully development and to work out control measures.

We followed routes covering the west bank of the Ob' from the village of Yeresten' 27 km. downstream to the village of Gon'ba, making observations from fixed natural and geodetic points at the Podglyaden' survey bench mark to the six gullies most typical of the region.

Inasmuch as the geological structure, hydrogeological conditions, and climate of the Ob' steppe are uniform, the fixed observations at the Podglyaden' survey bench mark can be regarded as a "key" to the entire region. They will also be characteristic of the development of gullies in other geomorphologically similar (4) areas of the Ob' steppe.

The west bank of the Ob' is characterized by the development of a typical steppe plateau with marks indicating the elevation of the exposed surface at 200 to 250 meters. This surface is transected by broad, parallel, gently sloping hollows extending northeast and southwest covered with sandy pine stands. These are the original river valleys of the tributaries of the Ob' river; they are of tectonic origin and are the basic drainage pathways of the region (3). The approximate depth of the waterways reaches 130 meters. The slopes are characterized by the presence of numerous large and small hollows, gullies and other forms of erosion produced by linear streams of water. Terraces have developed in the river valleys. There is a flood-plain terrace at 2 to 5 meters as well as four higher ones at 7 to 12, 12 to 15, 34 to 35 and 50 to 60 meters. There is some degree of dune formation on all the terraces.

The climate of the region is markedly continental. The temperature varies between −52° and +38°C. The winters are long and cold with constant snow cover and abundant snowstorms; the summers are hot with heavy rains. River conditions are characterized by long floods which sometimes last for four months, with variation in water level averaging 8.6 meters over many years, and with rates up to 3 meters. The riverbed is not stationary and meanders widely.

In the cuts made by the rivers and streams, the following elements can be seen in the geological structure from the top downwards: a formation of middle Quaternary loess-like compact clay loams, 40 to 50 meters thick, underlain by a formation of sands and loamy sands with interlayers of clay loam having a total thickness of about 80 meters. At greater depths, a formation of clay loams with buried soils can be traced up to 18 meters thick, sometimes disappearing from the profile. Beneath lie Lower Quaternary deposits which in the upper parts (within the river valley cuts) consist of "petrified clay fractions"—clays which are dense, silty, colored blue, cinnamon-brown, and yellow and which serve as a base for the overlying middle Quaternary deposits composing the slopes of the valleys in the steppe plateau (2).

The third and fourth terraces above the flood plain are composed of loess-like clay loams underlain by sands and loamy sand, while the first and second terraces are usually composed of sands or, more rarely, of clay loams. These terraces were formed at a time corresponding to the Altai glaciation and contemporary with the Würmian stage (2).

The hydrogeological conditions in the Ob' steppe cuts made by rivers and streams are characterized by a basic water table on the "petrified clay fraction," of localized temporary accumulations of water in the sand and loamy sand formations with interlayered clay loams, of the ground water of the alluvial terraces and the talus of the small hollows, and of the water of the sand dunes. The emergence of the subsurface water onto the exposed surface is associated with the formation of numerous cases of earth creep, mudflow and landslides resulting in destruction of the slopes.

The four ancient erosional cuts of the Ob' river which are related to the Altai glaciation are connected with the formation of the four terraces above the flood plain and of numerous ancient ravines and gullies. The level of these cuts formerly served as a base line for the erosion in the ancient ravines and gullies formed at that time and preserved up to the present. The modern erosive cuts of the Ob' and its tributaries are associated with the formation of the valley flat and of the numerous gullies in its bank and bottom. When the river washes away the valley flat and terraces, the base line of the erosion of these gullies descends to the level of the river water and varies with it. Four surveys of the edge of the bank of the Ob' at the town of Barnaul from 1948 to 1950 showed that areas of the flats made up of sand and loamy sand alternating with interlayers of clay loam are washed away at the rate of 25 m. a year; for silt clay loam the rate is 7 m. a year; for the first terrace above the flood plain, composed of more compact clay loam, it is 3.5 m. a year; and at the base of the main slope of the valley, composed of "petrified clay fraction,"—solid clay—it is 0.5 m. a year. The most intensive washouts occur during floods when the riverbed sometimes alters its course through the flood plain.

Erosion by the Ob' river is the cause of numerous landslides and earth creeps of the main slope of its valley and terraces. Landslides occur annually, mostly as the flood recedes. At the lower parts of the slope they form piles of talus which are washed out and carried away by the water. Their place on the slope is taken by new landslide material formed by the descent of material detached from the upper part of the slope; this is then washed away in subsequent years. Isolated large landslides may stretch out along the bank for distances up to 125 m.

Earth creep is encountered in areas of eroding riverbank where the base of the prime slope of the valley or terraces adjoins impermeable dense clay—"petrified clay fraction." The creeps are usually associated with depressed places in the "petrified clay fraction" cover on which accumulations are formed of the subsurface water drained by the river. Their length along the shore varies from several dekameters to 270 m., their width to 120 m. Earth creeps usually occur unexpectedly: as the flood is receding and in the fall. The bare, steep riverbanks formed by landslides and earth creeps are composed of loess-like clay loams. Here, downhill from depressed elements of the microrelief of the steppe plateau and terraces there is rapid development of "washout pits," washouts, and gullies which are eroded by streams of snowmelt and runoff from heavy rains. Caves and funnels also develop the loessial karst. A lowering of the base line the erosion of gullies is also related to ear creeps and landslides from the terraces. Lar earth creeps often cause lateral displacement the streambed and create favorable conditio for washouts of the bank in new areas.

Across the loess-like clay loam slopes are we developed interlaced "paths." They are locat one below another separated by steep, ba banks and forming unique "steps" on the slop and rims of the ravines. These "paths" are form by the trampling of grazing animals and, mainl by minor slaking of the subsoil. The subsoil a pears on the slopes, when soaked by rain, throug the cracks in the sod cover and forms parall slides when the soil dries out during the h period of the year. The width of the "steps varies from 0.4 to 0.8 m., rarely reaching 1.1 1.4 m. The height of the vertical interval b tween them usually varies from 0.4 to 0.9 m rarely reaching 1.65 or even 2.2 m. The long tudinal slope varies from 0° to 16° and rarel to 20° to 28°, while the vertical slope is from 10 to 20° with a maximum of 36°. The angle of th "risers" between the steps varies from 40° to 76 and rarely reaches 90°.

Along the "paths," flow of snowmelt and run off from heavy rains concentrates resulting i formation on slopes and banks of washouts "washout pits," and karst funnels and caves i the loess-like clay loams. These are often th beginnings of gully formation.

Loessial karst is associated with recent cut in the slopes of river valleys and gullies, and wit artificial cuts and half-cuts for railroads an highways. On the sheer walls caves occur eithe singly or in groups; they are up to 0.7 m. wid and 7 m. long and begin on the slope close t the rim as steep funnels up to 5 m. deep and m. in diameter. Often caves begin with a "wash out pit" 3 m. deep and 1½ m. in diameter locate along a sheer slope. The caves are triangular rectangular, square or oval in shape dependin on the disposition of the fissures in the inidvidua rock layer. With an abrupt increase in the runof of rainwater the roof of the cave sometimes slide off and a washout is formed in its place some times becoming a gully, or its vertex if the cav was in the bank of a gully.

The natural history of the Ob' steppe regio makes possible the development of erosive form of the relief, and to some extent of gullies. This i associated with Glacial and Recent epochs. The depth of the cut made by Recent gullies reaches 55 m. and they extend up to 8.0 km.

The development of gully erosion is also considerably caused by the activities of man. Clearing forest and underbrush from slopes, plowing without using erosion control measures, overgrazing on slopes and extending roads, ditches and embankments across slopes cause snowmelt and rainwater to concentrate in linear streams. A final factor is the discharge of industrial and household sewage down slopes.

Analysis of the observations (on gullies at fixed natural sites and along the survey route in the "key" area) enable us to distinguish separate forms of gully development all of which are interrelated to some degree and which combine to cause the growth of gullies (4). These consist of:

1. Sheet erosion on bare gully banks and plowed-slopes of small valleys.
2. Rill erosion by snowmelt flowing down from the steppe plateau.
3. Rill erosion of the heads and branches of gullies by snowmelt from snowdrifts on the slopes and development of branch gullies by suffosion.
4. Talus formation from the sides of gullies as a result of undercutting at their bases by transient flow of water through the gullies.
5. Solifluction and snow erosion developing along bare gully banks at the edges of snowdrifts lying on them.
6. Fracture and creep of soil and plant cover along steep gully banks and slopes of small valleys at thawing.
7. Crumbling at the rims of gully banks caused by snowdrifts.
8. Talus formation from gully banks caused by changes in air temperature and soil moisture.
9. Slides of gully banks caused by suffosion at their bases.
10. Earth creep of gully banks.
11. Mudflow on gully banks at the points of emergence of subsurface water.
12. Fracture in the continuity of the soil of gully banks with freezing and the accumulation of snow in gullies and small valleys.
13. Blowing away of bare gully banks (deflation).

Short descriptions of these forms of development of gullies are given below in the order of their occurrence during the year, starting in the spring. It should be understood that the forms listed previously do not give a complete picture of the development of gullies. New forms will be revealed in further research.

Sheet Erosion on Bare Gully Banks and Plowed Slopes of Small Valleys. This form of gully development is related to the runoff of snowmelt from the steppe plateau and to the thawing of snowdrifts which accumulate in winter on the concave and plowed windward areas of the slopes. Snowmelt running off the surfaces of the slopes of small valleys and banks of gullies collects in tiny streams, washing aways particles of the bare and plowed soil, and forming rills on the slopes, from 1 to 3 cm. in width and depth and sometimes larger. The eroded subsoil collects as liquified matter on the surface of the snowdrifts in the gullies. If there is only a gentle slope on the surface of the snowdrift, the matter remains in place, but if it is steeper the matter creeps slowly down to the mouth of the ravine. The liquid subsoil mass is usually no longer than several dekameters long, 1.5 m. wide and 0.15 to 0.20 m. thick.

The duration of this type of development in spring is determined by how long it takes the snow on the steppe and the snowbanks in the gullies to thaw. In 1950, it lasted from May 5 to May 22.

Sheet erosion should be controlled by using a combination of forestry engineering methods—sowing grass and planting shrubs along slopes of the small valleys and banks of the gullies.

No one should be allowed to plow, deforest, plant gardens, or pasture cattle on steep slopes.

Rill Erosion by Snowmelt Flowing Down From the Steppe Plateau. This form of gully development takes place during the period when the snow melts on the steppe and the gullies are still full of snow, their banks not yet thawed. Snowmelt, running down the watershed and small depressions in the relief, infiltrates through the snow that fills the gullies and moving along in streams deepens the bottoms. The eroded soil is carried away under the snow in suspended state to the mouths of the gullies where it forms an alluvial fan. The most intensive removal of soil material takes place during the day when the sun shines. It stops at night when the temperature falls. Erosion of the sides of the gullies is hardly seen at all, since the upper, bare parts of the gullies are still frozen and the lower part is under snow. This diffuses the streams of snowmelt and prevents erosion of the gully banks.

The duration of this form of gully development is determined by how long it takes the snow on the steppe plateau to melt. In 1950 such rill erosion was observed from March 30 to April 18. The maximum amount of soil material removed from the gullies (calculated according to determinations of the amount of solid material removed at the highest daily temperatures) does not exceed 0.014 m.^{3} per running meter of gully.

This form of gully development should be controlled by diffusing, reducing or diverting from gullies streams of snowmelt that come from the steppe plateau.

Rill Erosion of the Heads and Branches of Gullies by Snowmelt From Snowdrifts on the Slopes and Development of Branch Gullies by Suffosion. These two forms of gully development take place simultaneously, the latter supplementing the former. At the beginning of spring when the soil is frozen, they are only weakly developed. Then, when air temperature rises, they become more extensive because of greater thawing of snowdrifts and soil, especially when it rains. At this time the vertical erosion is supplemented by lateral erosion, causing crumbling and accumulation of material from the bare rims of the gully banks.

The snowmelt, flowing in tiny streams from under the snowdrifts, cuts very small, hardly noticeable rills 2 to 3 cm. in depth and width. On depressed parts of the slopes, these streams form concentrated linear streams which provide a beginning for the heads of eroded gullies and their branches. In clay loams or loamy sands these gullies and branches usually end in a sheer wall up to 1.5 to 2 m. high surmounted by a small (15 to 20 cm.) recess of the soil layer which is more resistant to erosion than the underlying soil not connected with the roots of plants.

In this wall below the soil layer the oozing out of liquified soil is often observed because of suffosion, which occurs only with prolonged (although not abundant) flow of snowmelt infiltrating through the upper thawing part of the soil. Suffosion is not observed with the brief flow associated with heavy rains. Suffosion ceases at the heads of gullies and branches when the snowmelt stops flowing from under the snowdrifts and the soil thaws out. As a result of the erosion and suffosion by the snowmelt, the hea of the gullies and branches were shown (obse vations made in "key" area in 1950) to increa in length by up to 1.6 m. a year in loess-li clay loams.

A calculation of the maximum possible r moval of solid material shows that the amount it removed by snowmelt flowing along gulli in the spring and early summer of 1950 (Apr to June) reached 659 m.^{3} in a gully 350 m. lon During the same spring, the appearance these forms of gully development was noted the end of thawing of most of the snow on t steppe plateau. They ended when the descen of snowdrifts down the slopes ended. Evidentl this period is different every year.

Such an important loss of solid material dow gullies should be controlled by diverting th streams of snowmelt, and by planting appropr ate special snow shelterbelts with shrubs havin well-developed branching root systems fringin the slopes of small valleys and rims of gullie In many cases the local inhabitants can suc cessfully reinforce the lengthening heads gullies and branches having small watersheds b applying manure or straw mixed with wet cla loam. This protects the heads against erosio from concentrated streams of snowmelt.

Talus Formation From the Sides o Gullies as a Result of Undercutting a Their Bases by Transient Flow of Wate Through the Gullies. When transient stream of snowmelt and water from heavy rains ar discharged and the soil of the gully banks ha thawed—and also when waste industrial wate and sewage is discharged down the gullies—th banks are undercut and collapse, creating ac cumulations of loose material and landslides The loess-like clay loams slip down along th structural cracks, forming a diversionary wa above and lumpy rock fragments below, but san and sandy loams pile up under the angle of th natural slope. Clay soils are gradually eroded do not form talus, and have smooth surfaces a the banks.

Talus formation and landslides develop mos extensively on projecting parts of gully bank at junctures with branches, erosion taking plac on both sides of the projection. Talus formatio and landslides usually occur after gully bank thaw and end shortly after the passage of snow melt down the gully, but recur a short time late with the heavy summer rains in July and Au

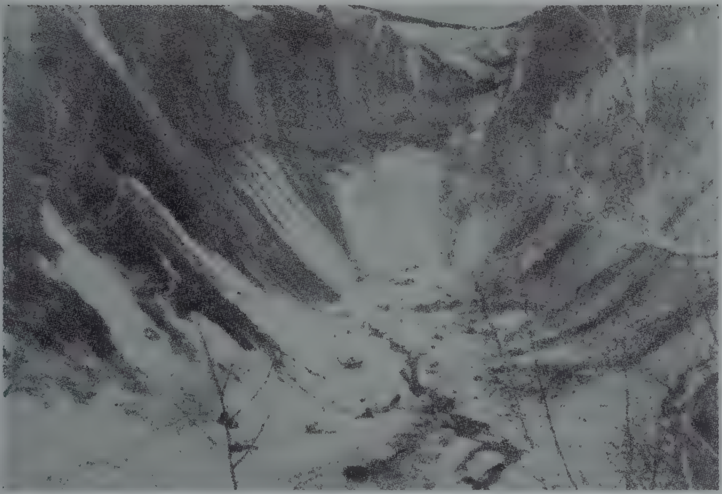

FIG. 1.—Soil flowing down over snowdrifts on the sides of a U-shaped gully as a result of snow erosion.

gust. In 1950 talus formation and landslides occurred most extensively in the middle of May, when the undercut banks of the gullies were drying out. As a result of this prominent form of gully bank development, the gullies grow up to 0.9 m. wider per year.

This must be controlled by diversion, diffusion, or reduction of transient streams from snowmelt and heavy rains by reinforcement of the gully banks with vegetation having branching roots.

Solifluction and Snow Erosion Developing along Bare Gully Banks at the Edges of Snowdrifts Lying on Them. By "snow erosion" we mean the liquefaction of the bare thawing soil of the gully banks or other bare slopes at the upper edge of the melting snowdrifts. This process is accompanied by landslides and slipping of the small saturated pieces of soil along the slanting snowdrift surface. The soil flows in solid streams to the gully bottom and even to its mouth (Fig. 1). This process is like solifluction, but differs from it in that the slipping of the soil occurs not only because it thaws, but also because of saturating snow melt (1). Usually these two processes are not separated in description but occur jointly, causing the widening of the gullies. Snow erosion occurs most intensively after the snow cover leaves the plateau and lasts until the end of the snowdrift thaw on gully banks (June and July).

If we determine the ratio of the volume of subsoil removed along the snow toward the mouths of the gullies to the unit area of the bare surface of the gully banks, we can calculate the thickness of the layer of soil carried down from the banks. According to our observations during the snowdrift thaw in 1950 (lasting until the end of July), the thickness of the layer removed reached 0.11 to 0.13 cm. In isolated areas it reached 1 m.

Snow erosion and solifluction must be controlled by sowing grass and planting bushes with branching roots along the bare gully banks.

Fractures and Creep of Soil and Plant Cover along Steep Gully Banks and Slopes of Small Valleys at Thawing. This form of gully development is a particular case of solifluction on sodded slopes. There is fracture of the sod cover when the soil thaws on gully banks and on the slopes of valleys' heads where the inclination is more than 30°. The fractures consist of fissures several centimeters wide and up to 0.24 m. deep. They cut across the valleys horizontally or are located along the upper margin of the thawing snowdrifts. In summer they are often filled as a result of soil creep down the slopes of small valleys. Grass grows in the fractures and they are no longer noticeable.

They are formed by the downward migration of the thawed water-saturated soil-and-plant layer as it passes over the still frozen earth of slopes inclined at more than 30°. On slopes where the angle exceeds 45° the soil-and-plant cover is detached. This results in the noisy movement of individual chunks as large as 0.75 $m.^2$ over distances as long as 90 m.

This type of flow reaches lengths as high as 35 m. (it is more often 21 m.) on slopes from 8 to 14 m. high. It is not more than 0.45 to 0.6 m. thick. The ground surface denuded of its soil-and-plant cover where the creep took place in gullies and on small valley slopes is inclined at 45° to 48° and becomes more nearly vertical in subsequent years. Sometimes such creeps recur.

This development of the gully banks and small valley slopes causes episodic widening in some areas of up to 0.5 m. and cannot be of any material importance in the enlargement of gullies and small valleys.

Flow of this type must be controlled by planting bushes with branching roots on the steep gully banks and small valleys and by flattening such banks to an angle which prevents fractures and slipping during thaw. In loess-like clay loams this angle is close to 40° but in coarser textured soils—sands and loamy sands—it is close to the angle of natural slope under water.

Crumbling at the Rims of Gully Banks Caused by Snowdrifts. This development of gullies is caused by the accumulation and sliding of overhanging, cornice-like snowdrifts at the rims of sheer areas at the heads and sides of gullies not eroded by snowmelt. In the daily thawing the bare bank is saturated and, at night, freezes. Then, with thawing and settling of the snow in the overhanging cornice, cracks appear along the rim. From this line the cornices fall to the gully bottom carrying away the earth crust frozen to them in a layer up to 8 cm. thick. In this way, 1 linear meter of the bare gully shoulder, having a snowdrift of up to 1 meter in thickness, can cause losses of up to 0.08 $m.^3$.

This development of gullies occurs at the end of thawing on the steppe plateau and ends toward the middle of April. On April 8, 1950 we observed fissures in the overhanging snowdrifts and saw them fall on April 10. By April 14 the overhanging snowdrifts on the gully rims were all gone.

This development is controlled by planting belts of bushes along the rims of U-shaped gullies or by the winter installation of sn screens like those used on the railroad.

Talus Formation from Gully Ban Caused by Changes in Air Temperatu and Soil Moisture. In early spring on ba gully banks composed of loess-like clay loam snowdrifts cover the bottom and lower part. C these are small, narrow piles of talus in the for of little tracks leading downward and consisti of bits of soil about 2 to 3 cm. in diameter. Som times larger bits are found on the gully botto amid such detritus. In a gully with high, stee bare banks in summer, there is a continuo rustling, caused by the descent of tiny bits soil. This accumulation stops in the fall whe the ground becomes moist.

This development is caused by a disturban of the ground compactness in spring because periodic thawing and freezing (with changi moisture from the snowbelt). In summer it caused by periodic moistening by rains, followe by drying. These accumulations occur most intensively where changes in the ground moistur are caused by summer rains and their infiltration through the plant and soil cover.

While this development does not cause gullie to grow noticeably, over a period of many year it undoubtedly causes widening.

It must be controlled by flattening the angl of the gully banks and at the same time by sowing grass on them.

Slides of Gully Banks Caused by Suffosion at their Bases. This development i caused by suffosion at the base of banks developing under hydrodynamic pressure at isolated areas where subsurface water emerges t the surface from sands and loamy sands. Wate removes soil particles at the base of the bank leading to settling of the soil above and the appearance of fissures along the gully rims from which there are further landslides. The clod falling to the bottom of the gully are eroded an transported by streams, or they are liquifie and flow to the mouth in the eroding water. I gully banks composed completely of sands landslides are not seen. In this case fracture are formed and there is movement along th slope of the sod cover resulting from the removal of sand from underneath it.

Slides and ruptures of the sod take plac episodically, more often in summer after heav rains, but they are being prepared continuousl by suffosion action.

Gully banks are widened by up to 10 m. a year because of this development. It must be controlled by installing at the base of the gully banks artificial abutments in the form of well-filtering berms and bulkheads with drainage fill for leading off the subsurface water.

Earth Creep of Gully Banks. This development is of two very similar types and leads to local widening at the sides of gullies.

The first type consists of creeping of the deposits on the bottoms of small valleys which occurs mostly on the eastern banks of bottom gullies; the second consists of creeping of the alluvium along the base on the western slopes of small valleys which the bottom gullies closely adjoin. The latter result from displacement at the gully banks of the alluvial cover laid over the basic deposits of the steppe plateau composing the slopes of small valleys with an angle of 30°.

The first type of creep takes in an area along the gully of up to 40 m. in length and up to 16 m. in width, with deposits up to 6.8 m. from the gully bank rims. The deposits of creep material on the bottom of the small valleys are usually in steps and dissected by longitudinal and transverse fissures.

The second type of creep extends up the slopes to a height of 23 to 27 m. from the gully bottom; it is 20 to 50 m. long and has considerable vertical displacement (Fig. 2). Both types are caused by undercutting the gully banks at their bases by transient streams and by the action of subsurface water. The water participating in the formation of the first type of creep is that from the alluvium of small valleys; that in the formation of the second type is ground water from the principal deposits. These types of creep occur in spring and summer after passage through the gullies of snowdrift melt and heavy rains. They are usually preceded by the formation of longitudinal fissures.

Control of the creep of gully banks should be by diversion or reduction of transient streams of snowmelt and rainwater passing along the gullies and eroding the masses of earth which have come down.

Mudflow on Gully Banks at the Points of Emergence of Subsurface Water. This form is encountered along the banks of bottom gullies where subsurfaced water emerges. The water-saturated clay loams are converted to a semiliquid mass and flow down the gully banks to the bottom. Here they are eroded down the gully by transient streams. Such flow is never more than 3 m. wide. At its origin it usually has a sheer wall of up to 3.5 m. in height below which is the liquefied earth mass. In spring, trickles of subsurface water can be noted in spots near the sheer walls; when they disappear in summer the mudflow stops. The increase in width caused by the mudflow from the gully banks at isolated spots varies from 0.5 to 1.3 m. a year.

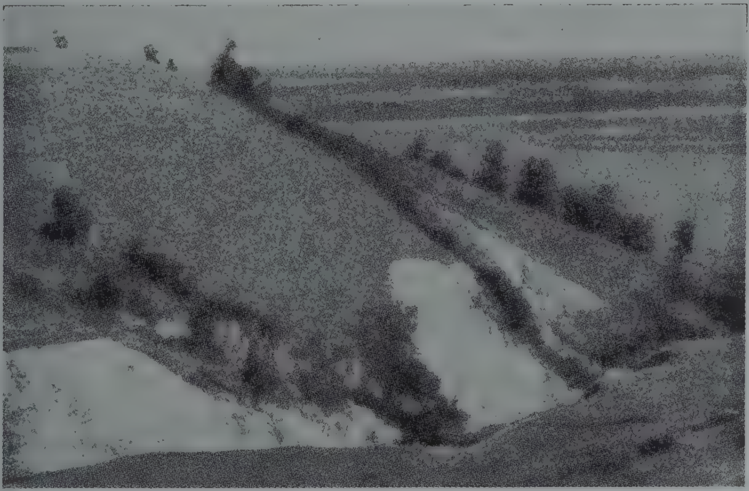

FIG. 2.—Earth creep of eroded material over the main soil type on the slope of a small valley.

Mudflow must be controlled by planting bushes and trees with branching roots and also by diverting the transient streams flowing down the gullies and eroding the mud at the bottom.

Fractures in the Continuity of the Soil of Gully Banks with Freezing and the Accumulation of Snow in Gullies and Small Valleys. In winter in the clay loam soils parallel to the frozen gully bank surfaces interlayers of ice crystals up to 5 mm. thick and 1 to 1.5 cm. apart develop. These can be followed to a depth of 0.3 m. below the exposed surface. These crystals fracture the soil, and it forms layers on thawing and slips down on the icy interlayers. On drying, the soil crumbles along the concealed fissures formed in place of the interlayers of ice. The groundwork for this development is laid in winter, but it does not occur until spring, when the snow melts and the ground dries.

There is also a passive development occurring in gullies and small valleys in winter and manifested in the accumulation of snow blown off the steppe plateau forming enormous, solid snowdrifts. In the spring of 1950 they filled the bottoms of the gullies and small valleys to a depth of 7 m. Snowmelt from these drifts is one of the main causes of gully development, so that the accumulation of snow in them which we consider to be a form of potential energy becomes kinetic on thawing.

These developments must be controlled by sowing grasses, planting bushes with branching roots on the bare gully banks and installing snow-protection belts along the rims of small valley slopes and the gully banks.

Blowing Away of Bare Gully Banks (Deflation). Blowing of soil from the bare gully banks and small valley slopes causes them to widen. This is very difficult to quantitate, especially during brief time intervals. However, for a preliminary estimate, we collected and measured the soil blown away by the wind from a definite area. Judging by these measurements, the maximum amount of soil blown from 1 m.^{2} a year under continuous wind conditions does not exceed 0.0025 m.^{3}, showing that the thickness of the layer blown away is 2.5 mm.

To make a quantitative estimate, on the day following a snowfall and the next night, which was very windy, we collected from a 0.25-m.^{2} area of the snow the soil blown from a bare outcropping of a small valley slope. The soil and snow together were dried at 105°C. in a dr ing oven and the dry weight of the blown soil w determined. Then we calculated the weight of tl blown soil for the entire area of snow which covered (12 m.^{2}). Knowing the area of the ba outcropping of soil (12 m.^{2}), and forming tl ratio per unit of its area of the weight of tl soil blown onto the snow (as well as its volum calculated from its density of 2.67), we obtaine the weight and volume of soil blown from 1 m of the outcropping. In this case it was 190.76 gr or 71.5 cm.^{3}

If we assume conditionally that strong wind blew every day, then in one year 1 m.^{2} of bar area of loess-like clay loam was lost 190.76 gm. 365 = 0.00667 metric tons or 0.0025 m.^{2}. This car not have much effect on gully development.

Actually, this amount of blown soil would b considerably less, since in winter the gully bank are frozen and covered with snow, while durin the rest of the year they are often wetted b rain so that wind erosion does not take place Further, it should be reduced by about 25% be cause of the number of windless days.

Wind erosion of gully bank soil should be con trolled by sowing grasses and planting bushes

Conclusions

From the preceding description of the dy namics of the forms of gully development on th Ob'steppe region it appears that for control o gully erosion, attention should not be confined to the eroding action of transient, linear stream of water. Consideration must also be given to other gully development caused by the action o subsurface water, air temperatures, snow erosion, the way the snow and rain fall, the direction of the wind, the microrelief, and other factors, and also by the activities of man. In each case attention should be devoted primarily to the leading forms of gully development which may differ in areas with differing natura conditions.

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SOME SPECIFIC CHARACTERISTICS OF THE MEADOW SOILS OF THE SOUTHERN MARITIME REGION

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THE SOILS of the Suifenho-Khanka lowland, which are marked by many unusual properties, require even more detailed study to provide a scientific basis for the application of agricultural engineering methods. As is well known, until recently the genesis and properties of these soils were very debatable. In the present paper we present some results of a field and laboratory study of typical meadow soils of the Southern Maritime Region.

The investigations were organized by the Soil Laboratory of the Far Eastern Branch, Academy of Sciences, USSR. Some analyses were done in the Soil Mineralogy Laboratory of the Soil Institute, Academy of Sciences, USSR, under the direction of Professors N. I Gorbunov and Yu. A. Liverovskiy.

The investigated meadow soils are distinguished by the following morphological characteristics:

Profile 21. located in Khorol district. Ancient terrace in the Mo river valley. This is a flat plain with microrelief consisting of small saucer-shaped depressions. The site has been overgrown for 15 to 20 years. The vegetation is of the meadow-steppe type and includes arundinella, *Koeleria* spp., "patriniya skabiozolistnaya," "man'chzhurskaya polyn' " and "razreznolistnaya polyn' " (Artemisia spp.), and also different types of mixed meadow herbage.

A_1 0–13 cm.

Dark-gray fresh fine clay loam, pulverulent and not water-stable: medium cloddy (10–30 mm. diameter). Transition to underlying horizon distinct.

A_1/A_2 13–23 cm.

Ash-colored dry fine clay loam, dissected by vertical cracks; clearly manifested columnar structure. Laminar; 2- to 3-mm. diameter pores. Accumulation of ortstein grains from 0.1 to 0.2 mm. in diameter. Clearly delimited from underlying horizon.

B_1G 23–39 cm.

Dark-gray with dark-blue tinge, moist, clay, dissected by cracks into small columns which break down into smaller prismatic structural elements; small ortstein grains are visible along the wall of the section; individual roots are seen along the course of which there is weak precipitation of vivianite. The transit is noticeable.

B_2G 40–53 cm.

Gray with faint brown tinge, quite moist cl Cheesy structure; somewhat friable. Isolat tongues go down to 60 cm. Transition to u derlying horizon gradual.

B_3G 53–92 cm.

Uneven gray-brown, very moist, cl cheesy; single roots encountered. Iron-ma ganese concretions of irregular bubble sha 2 to 3 cm. in diamter, are clearly seen. A depth of 53 to 63 cm. white specks, compos of $CaCO_3$ and effervescing vigorously w HCl, are encountered. The white specks a especially obvious as the sample dries o The transition is gradual.

B_4G 92–160 cm.

Heterogeneous, variegated with ochre a dark-blue spots. Clay; contains single sm black concretions, evidently manganes Transition is gradual.

CG 160–205 cm.

Dark-blue ochre, clay, wet; water oozes fro the wall of the section; many fine mangane concretions.

***Meadow soil* from the Maritime Experiment Station.** Vegetation of old overgrowth typ (Description by V. A. Kovda and Yu. A. Liv rovskiy)

A_0 0–3 cm.

Sod

A_1 3–20 cm.

Dark-gray fine grainy (0.5 to 1 mm.), fine cl loam. Lower border forms shallow pocket Transition clear.

A_1/A_2 20–28 cm.

Dirty-gray fine clay loam with mosaic colori from spots of humus and a large number fine rusty particles of ortstein; structure su angular blocky with small columns. Low limit vague.

A''_2/B 28–36 cm.

Yellowish, straw-colored, gray dense cla more homogeneous in color, many fine rust ortstein spots. Transition vague.

B_2 36–55 cm.

Darker than the preceding and more yellowis in color; dense clay with fine cloddy structur (0.5 to 10 mm.) Fine rusty ortstein spot Transition gradual.

B_3 55–80 cm.

Similar to the preceding but more cinnamo brownish in color. Clear dark-blue spots

TABLE 1
Results of chemical analyses of meadow soils

Profile No.	Designation of soil	Horizon	Depth, cm.	Humus, %	pH		Exchangeable cations as $\frac{\%}{\text{me.}}$				% removal of exchangeable cations
					Water	Salt	Ca	Mg	Na	K	
	Meadow with	A	0–14	5.35	6.10	5.30	—	—	0.027/1.27	0.005/0.13	—
o River	signs of bog	A_1–A	14–23	2.23	—	—	—	—	0.009/0.4	0.003/0.07	—
Valley	formation	B_1	23–39	1.81	—	6.10	—	—	0.039/1.8	0.009/0.25	—
		B_2	39–53	1.07	7.34	6.73	—	—	0.045/2.2	0.009/0.25	—
		B_3	53–63	0.69	7.95	6.98	—	—	0.041/1.9	0.008/0.24	—
		B_4	75–85	0.35	7.74	6.82	—	—	0.036/1.7	0.008/0.24	—
		C	110–120	0.46	7.45	6.50	—	—	0.028/1.3	0.007/0.19	—
			170–180	0.33	7.42	6.35	—	—	0.023/1.1	0.005/0.14	—
2[a]	Meadow slightly	A	0–7	—	5.69	4.99	0.284/14.7	0.013/5.67	—	—	44.03
o River	solodized with	A_2	7–16	—	5.67	4.91	0.22/11.1	0.0242/4.42	—	—	57.3
Valley	signs of bog	A_2G	16–28	—	5.86	5.74	0.23/11.2	0.0252/4.59	—	—	56.7
	formation	B_1	40–50	—	5.98	5.81	0.112/21.0	0.050/8.4	—	—	10.92
		B_1G	70–80	—	6.31	5.76	0.54/27.2	0.051/9.2	—	—	0.00

[a] From the collection of V. A. Kovda and Yu. A. Liverovskiy.

gley; structure large subangular blocky (>100 mm.), columnar. Transition vague.

80 cm.

Dark-blue dense clay with rusty-ochre and ochre-black spots from ortstein; structure cloddy, columnar.

As seen from the descriptions, a pronounced ibangular blocky structure which sometimes ikes on a columnar character is a characteristic iorphological peculiarity of the meadow soils of ie Suifenho-Khanka lowland. When the soil ries out the whitish horizon becomes stable. Vhen the lower horizons become dry there is a istinct occurence of an abundance of thin sili-ous grains which are not clearly visible in fresh rofiles. See Table 1 for characteristic chemical roperties of these meadow soils.

The soils are weakly acid, but in some cases Profile 21) become alkaline at certain depths. he humus content of the upper horizon is fairly igh—5 to 6%. It decreases with depth, at first iirly abruptly and then gradually, so that at 50 n. we still find 1% humus. The content of exhangeable cations (Ca and Mg) in the upper orizons reaches 20 milliequivalents. However, comparison of exchangeable cations in the soil orizons with those in the parent material shows iat a considerable amount has been removed om all horizons. This amount is highest in horione A_2 where it reaches 57%. There is also a onspicuous amount of exchangeable sodium in ie adsorbing complex. The high content of exhangeable sodium in the meadow soils of the uifenho-Khanka lowland was noted previously in papers by Liverovskiy (6) and Ivanov (4). See Table 2 on water extract analyses for the salt composition of these soils. The solid residue is small—from 0.04 to 0.09%—and changes relatively little in the profile. The total alkalinity varies from 0.18 to 1 milliequivalent. Calcium and magnesium predominate among the salts when the alkali content is low. The amount of alkalies increases noticeably only in the lower part of the profile. The anionic portion consists of sulfate and carbonate ions; the content of chloride ions is negligible. The results of total chemical analyses (Table 3) show that, according to the SiO_2 content, the parent material is acid. Actually, the Mo river valley receives the products of weathering of large surrounding areas of granite from which sediment is formed and then transported by the river. The parent material and lower part of the soil profile have a high concentration of iron. The lateral influx undoubtedly exerts a very strong influence on this. Furthermore, the upper (0 to 23 cm.) horizons of the soil show losses of iron and aluminum. Calculation of the molecular ratio SiO_2/R_2O_3 from the data of the total chemical analyses shows that the ratio decreases as you go from the upper horizons down through the lower ones. At a depth of about 23 cm. there is an abrupt drop in the value of this ratio (from 9.9 to 3.9). In the lower horizons at about 53 cm. a very small increase in the SiO_2/R_2O_3 ratio begins again, but only reaches 5.8 in the remaining depth of the soil. This is evidently due to the accumulation of SiO_2 which

TABLE 2

Water extracts analyses of meadow soils Suifenho-Khanka lowland

Profile No.	Horizon	Depth, cm.	Water sol. humus, %	Solid residue, %	After ashing, %	Alkalinity		Cl	SO₄	Ca	Mg	Na + K by difference	Na + K by spectroscopic method	Total salts,
						CO₃	Total HCO₃ as %/me.	as %/me.						
21 Mo River Valley meadow	A₁	0–14	n.d.[a]	0.082	0.031	none	0.017/ 0.29	traces	0.003/ 0.062	0.006/ 0.26	traces	0.0004/ 0.06	0.006/ 0.26	0.03
	A₁–A₂	14–23	0.026	0.057	0.028	"	0.02/ 0.33	"	0.001/ 0.016	0.003/ 0.10	"	0.005/ 0.21	0.008/ 0.36	0.02
	B₁G	23–39	n.d.	0.098	0.050	"	0.051/ 0.84	"	0.001/ 0.019	0.003/ 0.12	"	0.015/ 0.68	0.021/ 0.99	0.08
	B₂G	39–53	0.012	0.097	0.030	"	0.062/ 1.02	"	0.004/ 0.094	0.003/ 0.13	"	0.019/ 0.85	0.020/ 0.95	0.08
	B₃G	53–63	0.024	0.083	0.052	"	0.066/ 1.09	"	0.004/ 0.034	0.004/ 0.18	"	0.021/ 0.90	0.023/ 1.08	0.08
	B₄G	75–85	0.019	0.082	0.036	"	0.058/ 0.94	"	0.0027/ 0.056	0.003/ 0.17	"	0.017/ 0.74	0.020/ 0.95	0.08
	CG	110–120	0.021	0.083	0.021	"	0.044/ 0.73	"	0.0053/ 0.110	0.004/ 0.20	"	0.013/ 0.55	0.019/ 0.91	0.07
		170–180	0.016	n.d.	0.052	"	0.033/ 0.64	"	0.0061/ 0.13	0.005/ 0.27	"	0.012/ 0.50	0.018/ 0.83	0.06
202 Mo River Valley meadow	A₁	0–7	0.099	0.074	0.020	"	0.012/ 0.020	0.004/ 0.12	0.004/ 0.083	0.005/ 0.24	0.0021/ 0.17	none	n.d	0.027
	A₂	7–16	0.057	0.084	0.022	"	0.011/ 0.18	0.006/ 0.16	0.004/ 0.083	0.004/ 0.20	0.0019/ 0.16	/0.06	"	0.027
	A₂G	16–28	0.017	0.055	0.020	"	0.009/ 0.16	0.002/ 0.06	0.006/ 0.124	0.002/ 0.11	0.0013/ 0.107	/0.11	"	0.021
	B₁	40–50	n.d.	0.046	0.025	"	0.0134/ 0.22	0.003/ 0.08	0.003/ 0.06	0.004/ 0.17	0.0013/ 0.107	/0.08	"	0.026
	B₁G	70–80	n.d.	0.040	0.030	"	0.0103/ 0.18	0.002/ 0.06	0.004/ 0.083	0.003/ 0.13	0.0013/ 0.107	/0.29	"	0.020

[a] n.d. = not determined.

TABLE 3

A total chemical analysis in percentage of ashed matter

Profile No.	Horizon	Depth, cm.	SiO₂	R₂O₃	Fe₂O₃	P₂O₅	Al₂O₃	CaO	MgO	MnO	Total	SiO₂/R₂O₃
21 Mo River Valley meadow	A₁	0–14	76.71	15.26	7.79	0.118	7.35	1.09	0.58	—	95.36	10.42
	A₁/A₂	14–23	77.34	15.40	5.52	0.216	9.66	1.02	0.61	—	94.37	9.92
	B₁G	23–39	61.84	31.31	11.99	0.194	19.13	1.41	1.52	0.23	96.84	3.90
	B₂G	39–53	62.10	31.79	13.02	0.325	18.43	1.19	1.68	0.46	97.22	3.92
	B₃G	53–63	65.09	29.04	14.76	0.161	14.12	1.22	1.38	0.25	96.98	4.64
	B₄G	75–85	66.02	26.60	12.72	0.237	13.64	1.17	1.32	0.91	95.17	5.10
	CG	110–120	70.13	25.30	10.70	0.264	14.40	1.11	—	0.42	97.27	5.40
		170–180	69.75	24.26	10.48	0.235	13.54	1.35	0.99	1.91	97.66	5.80

precipitated from the solutions as a result of lateral influx of surface and ground water. The intermediate and lower horizons are also enriched in magnesium and aluminum. In the article by Kovda, Liverovskiy and Sun Da-chen (5), the meadow process in the soils of the southern plains of the Far East is maintained by the thick, slowly melting, seasonally frozen soil, which may be regarded as a unique horizon of ground water. Analyses of the surface and ground water from the Mo river valley showed that this water is characterized by a weakly alkaline reaction and contains noticeable amounts of salts.

A very important specific characteristic of soils of the Suifenho-Khanka lowland is the high content of iron-manganese concretions. Therefore, qualitative and quantitative studies were made. Table 4 shows that the maximum amount of ortstein is concentrated in the eluvial horizon—16 to 17% of the weight of the soil. Further down the profile the content falls to 0.5% and less. Table 5 shows the results of a total analysis of

TABLE 4

Percentage content of ortstein particles in samples of meadow soils

Profile No.	Soil	Depth, cm.	Diameter of ortstein particles, mm.						Total of fractions
			>5	5–3	3–1	1–0.5	0.5–0.25	<0.25	
26	Meadow soil from idle area (Maritime Experiment Station)	0–7	none	0.12	1.32	1.17	0.45	none	3.07
		7–17	"	0.10	1.73	1.10	0.73	0.26	3.9
		17–30	0.40	2.01	10.72	2.85	1.12	not det'd.	17.10
		30–43	0.86	none	9.04	1.73	0.64	0.04	12.31
		43–50	none	"	0.74	0.13	0.03	none	0.95
		55–70	"	0.02	none	0.18	0.06	0.02	0.29
		85–95	"	none	0.14	0.03	0.02	none	0.28
		110–120	"	0.05	0.15	0.26	0.03	"	0.24
		170–180	0.12	none	none	none	none	"	0.12
27	"	0–14	none	"	1.30	2.65	2.52	0.16	6.63
		20–40	"	0.15	7.01	4.67	3.76	0.61	16.20
		50–60	"	none	0.47	0.08	0.02	0.08	0.65
		70–80	"	"	0.17	0.08	0.09	0.03	0.37
		90–100	"	"	0.29	0.28	0.39	0.08	1.05

TABLE 5

A total chemical analysis of ortstein as percent of oven-dry weight

Designation of sample	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	P_2O_5	R_2O_3	MnO	Total
Ortstein layer, profile 27	52.28	23.71	13.64	4.87	2.04	0.20	37.57	0.75	97.51
Ortstein layer, profile 21	61.27	18.94	—	2.77	0.95	0.18	39.80	—	—
" particles >5 mm.	56.47	24.09	7.22	0.84	1.78	0.21	31.52	8.08	98.70
" " 5–3 "	57.97	18.07	11.67	0.82	—	0.15	29.89	6.20	94.88
" " 3–2 "	57.46	26.13	5.29	0.91	1.46	0.14	31.56	—	91.39
" " 2–1 "	53.80	29.16	10.11	0.84	1.34	0.21	39.48	0.61	96.07
" " 1–0.5 "	49.04	38.94	8.40	0.63	0.88	0.17	47.51	1.34	99.40
" " 0.5–0.25 "	56.16	31.81	9.48	0.88	0.78	1.05	42.34	0.21	101.36

ortstein particles divided into fractions of various diameters. In general it shows the uniformity of their chemical composition. It is only when there is a change in diameter of the ortstein particles that their composition changes noticeably, although this varies for different elements. The silica content changes relatively little, but that of iron increases noticeably with a decrease in diameter of the ortstein particles. Phosphorus behaves like iron. Aluminum does not display a clear pattern of change. The amount of manganese, on the other hand, decreases abruptly with a decrease in particle diameter. For ortstein in general there is a characteristically high content of iron, varying in different fractions from 18 to 38%, whereas the manganese content reaches 8% in the large particles and 0.2% in the small ones. The phosphorus content of the ortstein is fairly high. The ortstein of the Maritime soils differs noticeably from that of the podzolic soils studied by Gemmerling (2). The formation of ortstein is probably related to the gradual crystallization of amorphous iron gels. This hypothesis is confirmed by our experiments. Table 6 shows that a 0.2*N* HCl dissolved a relatively small part of the iron of ortstein—35 to 50 mg. per 100 gm. sample, or 0.19 to 0.22% of the gross iron content.

TABLE 6

Mobile iron in ortstein by Kirsanov's method

Fraction diameter, mm.	Fe_2O_3 in mg./100 gm. of ortstein with treatment		
	1 min. by 0.2 *N* HCl	1 hour by 0.2 *N* HCl	1 hour by 1 *N* HCl
>5	50.00	100.00	1000
5–3	31.25	—	—
3–1	50.00	—	—
1–0.5	50.00	—	—
0.5–0.25	50.00	—	—

The use of more concentrated extracts and extended treatment led to a sharp increase in the amount of iron extracted both from ortstein and from the soil as a whole. When ortstein was treated with 1*N* HCl it dissolved up to 1000 mg. of iron, which was 4.5% of the total iron content. An examination of microscopic sections of ortstein particles more than 0.5 mm. in diameter (by Ye. I. Parfenova, to whom thanks are expressed) confirmed the data from our chemical analysis which showed considerable crystallization of the iron compounds in the ortstein. Since the formation of ortstein is connected with the coagulation of mobile forms of iron, we became interested in seasonal changes in iron compounds.

TABLE 7

Mobile iron in Maritime meadow soils in milligrams per 100 grams of soil

Depth, cm.	Treatment	Date			
		May 15	July 15	Aug. 15	Sept. 15
0–10	Ordinary tillage	7.5	10.0	2.5	8.0
10–20		10.0	10.0	2.5	10.0
20–35		10.0	7.5	2.0	7.5
65–75		7.5	2.5	2.0	8.0
90–100		—	2.5	1.25	—
0–10	Deep tillage	10.0	10.0	2.5	7.5
10–20		10.0	10.0	3.0	8.7
20–35		10.0	7.5	3.0	6.25
65–75		5.0	5.0	3.0	7.5
90–100		—	2.5	2.5	—
0–10	Idle area	10.0	15.0	3.5	7.5
10–20		15.0	15.0	8.0	8.75
20–35		15.0	15.0	20.0	8.75
65–75		10.0	10.0	15.0	7.5
90–100		—	7.5	7.5	—

TABLE 8

Dynamics of reduced forms of iron oxide in Maritime meadow soils

Plowing treatment	Depth, cm.	Iron in mg./100 gm. on				
		Aug. 16	Aug. 17	Sept. 14	Sept. 17	Sept. 19
Ordinary	0–10	3.75	5.00	7.5	3.75	0.12
	10–20	5.0	3.75	7.5	3.75	0.12
	20–35	5.0	3.75	3.75	3.75	0.10
	65–75	—	—	3.75	—	—
Deep	0–10	3.75	3.75	7.5	3.75	0.08
	10–20	3.75	5.00	7.5	3.75	0.08
	20–30	3.75	3.75	3.75	1.87	0.07
	30–40	3.75	3.75	3.75	—	—
	65–75	—	—	—	—	—
Idle area	0–10	3.75	3.00	6.25	3.75	0.12
	10–20	3.00	3.00	6.25	3.75	0.12
	20–35	3.75	3.75	7.5	3.0	0.10
	65–75	—	—	7.5	—	—

No studies have been made up to the present time of changes in iron of Far Eastern meadow soils. Novikov states (8) that in the meadow soils of the Zeya-Bureya plain even during the period of considerable excess moisture from the summer monsoon rains, a high oxidation-reduction potential is preserved and no ferrous oxide is present. In our 1956 experiments, which were set up on the grounds of the Maritime Field Experiment Station, we determined the mobile iron content by Kirsanov's method at four different times during the growing period, using the following three treatments: 1) ordinary tillage to 18 to 20 cm.; 2) deep tillage to 40 to 50 cm.; 3) idle area. The results showed that the mobile iron content of the soil undergoes considerable seasonal variation (from 2.5 to 15 or 20 mg.). Incidentally, the tillage to 18 to 20 cm. and 40 to 50 cm. under our conditions did not exert any marked effect on the amount of mobile iron (Table 7). In all treatments, the amount of mobile iron decreased sharply during the third period (Sept. 14), evidently because of drying out the soil. Along with the determination of the mobile iron, we studied changes in its ferrous oxide forms. The determinations were carried out in 0.2*N* hydrochloric acid with 2,2′-bipyridine. These showed that the total content of ferrous oxide is considerable, although it is subject to abrupt seasonal variations (Table 8). Thus, our observations showed that the total content of mobile iron compounds is subject to considerable variation in the meadow soils of the Maritime region during the growing period. The participation of iron in the soil solution is undoubtedly very important for the specific features of the soil-forming process in this area. Gorbunov (3) considers that in a warm, moist climate sesquioxides crystallize into gibbsite and göthite. We tried to clarify the condition of the sesquioxides in the soils studied. Experiments were set up to extract aluminum and iron with solvents of various concentrations—1*N* KCl, 0.2*N* HCl and 1*N* HCl. Table 9 shows that a considerable part of the aluminum and iron compounds are in very stable, probably crystalline form. That is why a negligible amount of sesquioxides dissolved when solvents of low concentration were used. With more concentrated solvents the sesquioxide content in them increased tenfold.

Many years of experimenting with phosphorus fertilizers at the Maritime Experiment Station have shown that phosphorus is the most indispen-

TABLE 9

Solubility of iron and aluminum compounds of Maritime meadow soils

Soil	Depth, cm.	Al_2O_3 in mg./100 gm.			Fe_2O_3 in mg./100 gm.		
		1 *N* KCl	0.2 *N* HCl	1 *N* HCl	1 *N* KCl	0.2 *N* HCl	1 *N* HCl
Meadow soil, Maritime Expt. Station	0–10	0.265	153.0	342.0	none	15.0	175.0
	23–32	4.387	139.0	904.5	none	22.0	175.0
	23–32 without ortstein	—	108.0	—	—	15.0	125.0
	56–75	13.29	180.0	1246.5	—	25.0	1000.

TABLE 10

Results of P_2O_5 adsorption by meadow soils

Profile No.	Depth, cm.	Sample weight, gm.	P_2O_5 applied to soil, mg.	P_2O_5 remaining in solution, mg.	P_2O_5 adsorbed per 5 gm. of soil	Recalculated per hectare: furrow-slice of P_2O_5 applied, kg.	Possible adsorption of P_2O_5/hectare: furrow-slice
202 (Mo River Valley)	0–7	5	1.4	0.60	0.8	840	480
	16–28	same	same	0.24	1.16	not det'd.	696
27 (Maritime Experiment Station)	0–10	"	"			"	
	23–32	"	"	0.25		"	
	ortstein	"	"	not shown		—	—
	"	"	2.5	"			
	"	"	5.0	0.1	4.9	—	2940

sable element for Maritime meadow soils, regardless of their high total phosphorus content. Furthermore, nitrogen without phosphorus sometimes does not have a positive effect on the crop yield at all. Hence, in this respect, too, Maritime meadow soils are the opposite of sod-podzolic soils. To determine the causes of the low mobility of phosphorus in Maritime meadow soils, experiments were done with phosphate adsorption. As adsorbents we used: 1) soil in its natural condition; and 2) ortstein sorted from the soil. We added 0.01*N* $Ca(H_2PO_4)_2 \cdot H_2O$ to 5 gm. samples. They were then agitated for an hour on a rotator and allowed to stand for 24 hours. Phosphorus content was determined by Truog's method.

Results (Table 10) show intensive adsorption of phosphorus by all meadow soil samples and especially by the ortstein particles. The rate of phosphorus adsorption by separate horizons was in direct proportion to the percentage of ortstein they contained. We assume that the deficiency of mobile phosphorus compounds in Maritime meadow soils is due to the fact that phosphorus forms stable organic compounds. However, the results indicate that the maximum adsorption of phosphorus on meadow soils is due to aluminum and to iron as ferrous oxide. A calculation of the amount of phosphorus that can be adsorbed per hectare-furrow-slice is very indicative: the amount is enormous—from 480 to 804 kg. per ha. These figures are approximate. We were obliged to use abnormally high initial phosphate concentrates, since amounts not corresponding to those normally used in large-scale agriculture would have been impossible to determine even with an electronic photocolorimeter.

To show the degree of stability of the attachment of phosphorus adsorbed by the soil we did the following experiments: After a sample was saturated with phosphate, it was treated with three solvents in succession: 1) buffered acetate; 2) acetic acid; and 3) citric acid. Askinazi and Ginzburg (1) show that with buffered acetate extract at pH 4.75 it is possible to determine sol-

TABLE 11

Results of adsorbed phosphate displacement

Profile No.	Depth, cm.	Mg. of P_2O_5 adsorbed per 100 gm.	P_2O_5 dissolved in mg./100 gm.		
			Buffered acetate extract	Acetic acid extract	1% citric acid extract
202 (Mo River Valley)	0–7	16.0	3.0	2.4	11.0
	16–28	23.2	2.3	1.2	9.0
27 (Field Expt. Station)	0–10	23.0	2.3	1.8	18.0
	23–32	26.8	1.5	1.2	8.0
Ortstein		98.0	0.8	1.0	not shown

uble calcium phosphates. With $0.5N$ CH_3COOH (pH 2.5) there is complete extraction of all of calcium phosphates partially bound to apatite, and also of aluminum phosphates. One percent citric acid (pH 2.3) extracts not only all of the preceding phopshates, but also the basic and neutral iron phosphates (vivianite), and manganese phosphate.

Table 11 shows that Maritime meadow soils, even those saturated with phosphorus, contain a negligible amount of mobile phosphorus (3 to 5 mg.). The amount of mobile phosphates changes sharply with the horizon. Whereas the amount of phopshate in the upper horizon is in direct proportion to that adsorbed, in the lower horizons the reverse relationship is true. The reason is that the upper horizon of Maritime meadow soils contains less ortstein, which is the basic adsorbent of phosphates. In samples of the upper horizons a large amount of phosphates is also combined with iron, as shown by the data from the 1% citric acid extract. However, the adsorbed phosphorus does not form sufficiently stable compounds here. Ortstein absorbed 98 mg. of P_2O_5 per 100 gm., but there were only insignificant quantities of the mobile forms of phosphorus in it. No traces of phosphorus were found in the 1% citric acid extracts.

It might be assumed that at low pH values not only phosphorus but also iron is dissolved, the latter interfering with the determination of mobile phosphates. We did the following experiment to clarify this assumption. The ortstein samples which had been treated by the three extractants (buffered acetate, acetic acid, and citric acid) were extracted with $2N$ HCl. This liberated the adsorbed phosphorus. In Novak's opinion (9) aluminum is the principal adsorbent of phosphate in our soils. However, the data of Table 11 enable us to draw a different conclusion. We detected a total of 1.8 to 2.4 mg. of P_2O_5 per 100 gm. of soil in the acetic acid extract (which made it possible to determine the phosphates combined with aluminum). There was a five- to tenfold increase in the phosphate content of the citric acid extract.

Conclusions

1. The following are important specific characteristics of the meadow soils of the Suifenho-Khanka lowland:

a. A large amount of exchangeable alkali.

b. A high content of iron-manganeses concretions which differ qualitatively in composition from the ortstein concretions of podzolic soils.

2. Until now there has been no explanation as to why phosphorus, and not nitrogen, is most indispensable for Maritime meadow soils. Our investigations show that this is caused by the adsorption of phophorus by sesquioxides, principally that of iron.

3. Therefore, to ensure the effective action of fertilizers on Maritime meadow soils, consideration must be given to their high adsorptive capacity with respect to phosphorus.

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EVIEW OF PAPERS ON SOIL GENESIS IN VOL. V OF THE ROCEEDINGS OF THE SIXTH INTERNATIONAL CONGRESS F SOIL SCIENCE

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THE past decade has been remarkable for the appearance in the foreign literature of a otable number of publications on soil genesis. hese publications include such significant works s the two monographs by Kubiena [5, 6]; "Derminative Manual and Taxonomy of the Euroean Soils" and "The Soils of Europe," Durand] "Geological, hydrological and pedological udy of Algerian soil crusts," Mohr and van aren [7] "Tropical Soils," Jenny [4] "Factors of oil Formation," and others. Some of them have lready been reviewed in Soviet literature (Pochovedeniye, 1956).

Great attention was also given to soil genesis t the Sixth International Congress of Soil Scince held in Paris in 1956. Most of those reportg to the Fifth Commission discussed this queson at least to some extent. It seems to us that e reports outline the general status of the roblem and will thus prove interesting to Soviet eaders. In the present article we limit ourselves elucidation of the reports presented by foreign ientists on the subject of tropical, subtropical nd temperate regions.[1]

Soil Formation in Tropical Regions

The attention of the Congress was centered n laterization processes, lateritic crusts and iron ans, the evolution of lateritic soils and so forth.

D'Hoore [24]. This paper, devoted to the soils f the humid tropical forests of the Belgian ongo, discusses the fundamental peculiarities f tropical soil formation, establishes the great iversity in the mineralogical composition of the arent materials and the wide distribution of lict (fossil) soils.

The influence of the forest, with its high humidity and temperature (25°C.), is very important and is the fundamental factor preventing the complete laterization of present-day soils. Under the action of abundant acid waters which cause leaching and the action of complex organic-iron compounds, the mineral framework of tropical soils undergoes profound destruction. As a result of this it consists of kaolinized clay, quartz and some other residual minerals. There is a characteristically feeble accumulation of free sesquioxides localized on the surfaces of "clay crystals." The more significant iron accumulations found in some profiles of tropical soils are considered a legacy of previous soil formation, or the result of introductions by lateral flow ("absolute accumulation"). Under forest, kaolin clays are stable; after the forest is cleared they undergo partial disintegration and the sesquioxide products give rise to concretions and iron pans. At the same time, intensive erosion develops.

The migration of Fe_2O_3 plays a prominent role in tropical soil formation. The migration of sesquioxides takes place in the form of complex combinations with organic substances. The transfer of these compounds to lower layers leads to the precipitation of hydroxides from solutions and to cementation by them of the soil particles. Iron pans are thus formed, which previous authors related to the final results of laterization. Present-day lateritic iron pans are formed on rocks rich in Fe_2O_3. Many of the iron pans are not modern, but have an ancient origin in the Tertiary period. The majority of the ancient iron pans were formed exactly the same way as the modern. Ancient and modern iron pans may serve as parent rocks for other soils. Fragments of ancient iron pans have a rounded form and are sometimes mistaken for modern concretions formed *in situ*.

D'Hoore proposes to distinguish two categories of soils: those "of the first cycle" of soil formation, without any traits of previous soil formation, and those "of the second cycle," with superimposed soil formation, that is, with features of ancient soil formation.

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[1] In order to distinguish them from the refernces listed at the end of this article, in the followg text we shall mention in brackets the serial umber of the paper as presented in Proceedings f the Fifth Commission of the International Conress of Soil Science (VI-e Congrès International e la Science du Sol, Rapports, Vol. E, Comm. V. aris, 1956).

Maignien [76], like D'Hoore, considers that the formation of present-day iron pans in French Guinea and the Sudan is linked to the lateral additions into the lower parts of the contour of iron and manganese from the high surfaces of the Tertiary age, and which have ancient iron pans. The formation of present-day iron pans proceeds chiefly in slopes of less than 8° at the foot of mountains; here, cementation is compact. Lower in the contour, for instance in terraces near the Niger river, iron pans are less developed and the fainter they are, the younger the terrace. In the very young terraces only stains of iron cement are formed. It has been established that lateral movement of solutions proceeds along the slope because the vertical drainage is rendered difficult owing to the deep saturation of the soils with water and also to the presence at some depth of a compact clay horizon. Under such anaerobic conditions the organic matter has an acid reaction, is easily dispersed, forming complexes with Fe and Mn, and possesses high mobility. The formation of iron-rich horizons takes place as the result of oxidation, followed by mineralization of the organic reducing complexes. In various soils iron pans are formed at the junction of the hydrostatic level, where variations in pH are greatest. The author proposes to divide the iron pans into monogenetic, formed in homogeneous soils, and polygenetic (cementing various soils).

Kubiena [39] describes a peculiar process—"reddening." Reddening (Rubefizierung) is the property of subtropical soils which manifests itself in the change of their color from cinnamon-brown (brown) to reddish and finally to a shrill red. Reddening takes place in an alternately humid climate and in easily permeable, easily warmed soils, rich in iron. Under these conditions, peptized amorphous iron hydroxides lose water and separate out in the form of extremely fine hematite crystals with the property of intense coloration. Reddening appears first in the form of separate spots but then is uniformly distributed throughout the entire soil mass. In thin sections observed by transmitted light, areas ranging from bright to bright-red are visible.

Laterization (Lateriesierung) proceeds under tropical conditions in soils and subsoil layers which have a good, uniform, steady moisture. As a result of slow aging, amorphous hydroxides a dehydrated and change over into the crysta line state. During laterization, the formation larger crystals and their aggregates (and le hematite) is observed more than during redde ing. The deposition of such slowly developi opaque iron hydroxides is associated with fissur and large cavities, and the deposit is not distri uted throughout the whole soil mass, as it is reddening. Morphologically these deposits ha the form of threads, nets, coatings, lumps ar slags. Laterization is accompanied by a high ra of migration of peptized amorphous iron hydro ide, which may lead to its almost complete eluv ation. The high mobility of peptized iron hy droxide is especially conspicuous during the fir phase of laterization. In the process of agin silica is converted into opal (if for some reaso its eluviation is arrested), and then into cha cedony or secondary quartz; this process is neve observed during reddening.

Gallego [78]. In the locality of Bata, Guinea four samples were taken which, in the opinion o the author, corresponded to definite phases o laterization: A, ancient laterite; B, main mass o laterite with spots of ancient concretions pene trating into the mass; C, fresh (primary) brow clay; D, new concretions formed from brow clay. As a result of the investigations, the au thor concludes: 1) from the primary brown cla (C) brown concretions are formed with a high (35%) content of free iron hydroxide, very similar in composition to the main laterized mass (B); 2) the laterization process is possible without the eluviation of silica; 3) kaolinite remains unchanged and immobile during the whole process; 4) according to thermal analyses all samples contained kaolinite, goethite and aluminum hydroxide.

Riquier [88]. The investigations were conducted in the neighborhood of Lake Alaotra, Madagascar, in four terraces 760, 800, 830 and 900 meters in altitude, respectively, while the level of the lake water was 750 meters. Specific characteristics of the climate are: mean annual temperature, 21°C., rainfall, 1150 mm. and a dry season which lasts 4 to 5 months. The author gives an outline of the development of the soils correlated with the age of the surface. Two series of soils are distinguished: hydromorphic, on present day terraces; and lateritic, on ancient alluvium and related to terraces 830 to 900 meters in altitude.

The author concludes: 1) the moisture factor ts rapidly, since in a few years the soil may ready become hydromorphic-gleyed; 2) lateri- tion is, on the contrary, a very slow process, hich may continue in this case throughout the hole Quaternary period; 3) the time factor ust be considered in relation to the rapidly oceeding processes (gleying), as well as to the ower ones (laterization); 4) different soils olve differently. Thus, in the vicinity of ground ater the soils acquire podzolization features in e initial stages of their development; they are en converted (on a terrace at 755 meters) into esent-day podzols and also remain podzols on cient terraces (at 830 meters). For instance, e less hydromorphic soils of the lower terraces ange over to lateritic on the ancient terraces.

Berlier, Dabin, Leneuf [81]. On the littoral the Ivory Coast, both forest and grassy sa- nna soils were studied. Savannas are consid- ed relics of a drier climatic period, when the velopment of forests was difficult. (At present e rainfall reaches 2000 mm.) The soils belong the tropical, leached, weakly laterized, with pH of 3.9 to 4.9 under forest and 4.0 to 4.9 der savanna; the corresponding organic car- n content in the respective 0 to 10 cm. horizon 1.2 to 1.8 and 0.9 to 1.4%. Associated with this, ere is a variation in the exchange capacity: 9 to 1.4 me. under forest and 1.3 to 2.0 me. der savanna. The exchange capacity in the wer part of the profile is almost uniform and ry low: 0.4 to 0.6 me. The soils have the fol- wing profile: 0 to 10 cm., gray to cinnamon own (brown); 10 to 40 cm. cinnamon brown- herous; 40 to 300 cm. ocherous with various on spots. Iron pans (cuirasse ferrugineuse, nzerdecke) are observed under forest as well under savanna. In all the soils the deep layers e markedly more clayey than the upper ones. Savanna soils are more leached than forest ils. Intensified biological activity of forest soils d particularly of nitrogen-fixing microorgan- ns was observed. Forest soils are more fertile ring the first years of their utilization than e savanna soils.

Alexander, Cady, Whittig and Dever [11]. he authors studied various types of African terites. Depending on their structure, laterites e subdivided into saprolites and oolites. Sapro- es are formed by the weathering of coarse- ained parent rocks, chiefly granites. Here, as rule, the structural elements of the original rock are retained. Characteristic of this saprolitic laterite is the presence of goethite, gibbsite and kaolinite, formed as pseudomorphs after the minerals of the parent rock. The most important of them are goethite and kaolinite. Quartz is present as an inheritance from the parent rock. Oolitic laterites are more rigid; their structure is formed by oolites, concretions and various bodies containing primary minerals. Bemite predominates among the secondary minerals. There is some of goethite, gibbsite and amorphous clay iron minerals. Kaolinite is absent or found in traces.

The hardening process was studied. According to the authors, the difference between "lateritic crust" and "earthy laterite" depends not so much on the mineralogical composition as on the structural distribution of hydrates of iron oxides and on the small clay content of the lateritic crusts. The main role in hardening is played by dehydration. The hardest crusts contain much hematite and bemite.

Hoyos and Alias [62]. Lateritic concretions from three profiles were studied by means of HCl extracts and thermal and X-ray analyses. Great fluctuations were shown in the total silica and sesquioxide content of concretions from various laterites. The ratio $SiO_2:Al_2O_3$ varied from 1.7 to 1.9 all the way to 3.4 to 5.8 and the amount of Fe_2O_3 from 40 to 60%. According to data from thermal analyses, the composition of the concretions includes kaolinite (55 to 75%), goethite (20 to 40%), and in two of the four analyses lepidocrocite was found (10 to 20%). X-ray plates confirmed the presence of kaolinite and goethite. Lepidocrocite and goethite are formed by the dehydration of peptized and mobile iron oxide depositing on the soil particles. At the same time, silica ages and changes into quartz in amounts proportional to the intensity with which the laterization of the primary brown clay proceeded.

De Craene and Laruelle [87]. Latosols (lateritic soils) with "atypical slag" have structureless upper horizons due to leaching, as was ascertained by microscopic examinations. This leaching occurs more easily in acid parent rocks than in alkaline. Textural and chemical analyses revealed some tendency towards a decrease of clay and iron. Thus, the development of the soils in the stage of "atypical slag formation" consists in a secondary change in the soil profile.

Anderson [15]. Two series of soils from southern Tanganyika are described: on quartz-enriched acid gneiss and on hornblende granite and amphibolite. The great thickness of the horizon containing iron concretions in soils on gneiss is linked to their periodical swamping. In agreement with D'Hoore, the formation of dense iron concretions is considered the result of "absolute accumulation" of iron oxides. The author concludes that the soils he describes belong to the group of non-lateritic red earths, widely distributed throughout East Africa. These soils contain about 10% mobile iron oxide. The chief mineral (according to Muir) is kaolinite. The ratio $SiO_2:Al_2O_3$ in the colloidal clay fraction is 1.8; but the ratio $SiO_2:R_2O_3$ is 1.4 to 1.6. These soils do not belong to the latosol group, which are characterized according to Kellogg, by a $SiO_2:Al_2O_3$ ratio of not less than 2, poorly stable aggregates and low sesquioxides content.

Leneuf and Ochs [86]. Forest soils on the sandy littoral of the Ivory Coast are described. Mean annual rainfall is 2000 mm., mean annual temperature is 26.9°C. and relative humidity is 80%. The water table is at a depth of 0.2 to 2.0 meters. Here are found humus-iron podzols and sandy podzolic soils on seaboard sands. The authors consider that the marked podzolic character of these soils is due to 1) the lack of cations in the parent rock, 2) the high permeability of water to quartz sands, 3) the large amount of rainfall and 4) the action of ground water, the level of which fluctuates seasonally with fluctuations of the water level in the lagoon. Coarse acidic humus accumulates on the soil surface.

Chiang Kwei Lee, Shio Ni Chang (Reprint of the paper presented at the Sixth International Congress of Soil Scientists. Peking, 1956). The red soils of China are subdivided into three groups: lateritic soils, red soils and pozdolized red soils. Among the lateritic soils red lateritic and yellow lateritic are distinguished. The former have developed on basalts and sandstones; the latter, on acid and leached parent rocks. Both types of soils have been leached, and the $SiO_2:Al_2O_3$ ratio of the clay fraction usually reaches 1.5 to 1.7. The clay fraction consists of kaolinitic clay and hydrated iron oxides. Red soils are formed on various parent rocks, and the $SiO_2:Al_2O_3$ ratio of their clay fraction is 1.8 to 2.0 (As may be seen, here is some discrepancy from Anderson's paper [15].) In the coarse fractions of these soils, primary minerals —micas and potash feldspars—are still found. The high acidity of red soils is due to act aluminum. Podzolized red soils are distribut throughout hilly localities. They are charact ized by a brownish-red gleyed B horizon; t subsoil is yellow and has iron concretions.

These reports show that during recent yea the study of tropical soils has advanced signi cantly, producing important results from t scientific as well as the practical point of vie The investigations showed that lateritic so are found on parent rocks of various ages a petrographic composition (igneous, limeston sandstones, schists) and even on modern se ments. Most authors emphasize the extraor nary importance of the time factor in lateri formation. It is also of considerable importan that in tropical soil formation many investig tors have described the large-scale migratio along the contour of organic iron compound These play an important role in processes "absolute accumulation" in the formation iron pans and iron crusts.

Much information is contained in Kubiena paper. It reveals specific characteristics of th "laterization" and "reddening" processes an their distinguishing features by the micromorphologic method. Kubiena's terminology i widely used by foreign scientists. Gallego's investigations on the phases of laterization are interesting, but this complex problem is not ye solved. The papers by Riquier, Anderson, Leneu and Ochs, as well as by other authors (as wa to be expected), showed the existence of grea differences in tropical soil formation, dependin on climate, topography, character of the paren rock, peculiarities of the water relations, and s forth.

It is to be regretted that almost no attempt was made in this Congress to illuminate the question of soil formation in primeval, natural savannas. This was discussed in part in the paper by Berlier, Dabin and Leneuf [81], but the authors describe a secondary savanna, deforested as the result of human activity.

No one can agree with D'Hoore's reproach that the "zonality principle" is not applicable to tropical countries. It seems to us that all the information submitted to the Congress confirms the validity of this principle. Naturally, one "zonality" by itself cannot reveal all the particular and local peculiarities of soil formation caused by the mineralogical composition of the parent rock, the character of the landscape, the nditions of the contour, the age of the area, d so forth.

Soil Formation in Subtropical Regions

The Congress devoted most of its attention to btropical soils, judging by the number of pa- rs presented, as well as by the diversity of estions involved. Of primary importance is a ies of papers devoted to problems of soil for- tion in the Canary Islands. In spite of their uthern location (27° to 29.5° north latitude), e climate of the Canary Islands is moderately btropical because of the influence of the cold rrent of the Gulf Stream. The mean annual mospheric precipitation is not large: it ranges om 194 mm. at Gran Canaria Island to 532 n. at Palma Island. Nevertheless, the climate's idness is mitigated by the high humidity owing the insular location. The eastern part of the and is drier than the western.

Kubiena [38] studied soils on basaltic lavas of rious ages, modern, Pliocene, Miocene and e-Miocene. On Pre-Miocene, Miocene and rtly in Pliocene lavas, widely distributed relics red loams (Rotlehm) were found. From this e author concludes that, in the western part the Canary Islands before the Pliocene, a hu- id subtropical and tropical climate prevailed. is brought about the formation of red loam ils. The author established the formation on eistocene parent rocks of brown loams. These e widespread at present but are markedly di- inishing, and being displaced by the brown uthern soils characteristic of present condi- ons. On recent lavas, soils have developed hich correspond to the present climate. In or- r of increasing xeromorphism they are: rank- s, pararendzinas, brown southern (meridionale raunerden) and carbonate brown soils (Kalk- aunerden).

Calvo del Carmen Sanchez [71]. A study was ade of soils on basalts, known as "brown loams" raunlehm), which together with "red loams" otlehm) are the most widespread soil types the subtropical Canary Islands. Among the own loam soils several subtypes are distin- ished:

1. Typical brown loam on basalt (Braun- hm). The soil is poor in humus, weakly acid in action and free of carbonates (a little carbon- e of secondary origin occurs only in horizon).

2. Earthy brown loam on basalt (erdiger Braunlehm). Absolute altitude, 880 m.; soil richer in humus and more leached; reaction from weakly acid to neutral. The $SiO_2:Al_2O_3$ ratio is 2 (in the clay fraction). The clay mineral is halloysite.

3. Earthy brown loam on basalt. Absolute altitude, 920 m. Compared to the soil just described, there are increases in humus content, in "earthiness" and in low content of cations. Its reaction is weakly acidic. There is even more iron and aluminum in the clay fraction. The kaolinite group predominates among the clay minerals.

4. Brown mull, ranker (Ramann Braunerde), is formed under drier conditions on basalt with a secondary accumulation of carbonates. These soils are considered transitional toward southern brown soils. The author concludes that in the Canary Islands the soil cover undergoes an evolution from "typical brown" through "earthy brown" to "southern forest brown."

Hoyos and Soler [49]. The authors were interested in the evolution of brown soils on basic parent rocks. Soil profiles from the islands Gran and Palma of the Canary group were studied. The most characteristic profiles are: a) in the eastern part of Gran Island, "weakly developed brown" on porous lapilli; the vegetation consists of plaintain and sempervivum; b) in the southeastern part of Palma Island on basaltic lava from the volcano Martin (eruption of 1667); the vegetation includes *Pteris aquilina*, pine trees, mosses and lichens; c) in the northeastern part of Palma Island, "southern forest brown" soils of the Central European type on basalt; the vegetation includes humid laurel forest.

The authors conclude that in a subtropical climate with scanty rainfall, weakly-developed brown soils are formed. They are superficial, with appreciable amounts of coarse fractions, and are accompanied by the formation of clay minerals of the illite type and of coarse humus. Sufficient rainfall gives rise to brown forest soils almost of the Central European type but with a higher content of fine fractions, rich in mull and with a kaolinite type of clay.

Hoyos and Mata [48] studied products of weathering from the crater of a volcano in the Canary Islands (Tenerife). They concluded that the sulfurous gas which escapes from the fumaroles is oxidized to an acid which acts on the volcanic rock rich in potassium and leads to the formation of alunite. Weak acid concentrations give rise to kaolinite.

Hoyos, Rodriguez, del Pino and Soler [61] studied tropical and subtropical soils on basic rocks (basalts and basaltic lavas) of Guinea and the Canary Islands. In Guinea, under tropical climatic conditions with alternating dry and moist periods (2500 to 6000 mm. rainfall), yellowish, brown and red kaolinitic clays are formed (38% of the fraction is smaller than 0.002 mm.); they have an appreciable content of colloidal silica.

In the Canary Islands with a rainfall of 170 to 500 mm. "southern brown" soils are formed. They are weakly developed, less thick and less clay, containing 24% clay (<0.002 mm. diameter); relatively less intense weathering leads to the formation of clay of the illite type. The hydrated iron compounds are coagulated. The adsorption capacity is higher than in Guinea soils. As in Guinea soils the pH lies within the acid range, 5.1 to 6.2. In some localities yellow clays with gibbsite like those of Guinea are found. They are considered as relic formations from that period when there were uniform climatic conditions in those two regions.

Albareda, Alvira, Arevalo [94]. Fifteen soil profiles from the arid regions of southern, central and eastern Spain were studied. According to Kubiena's nomenclature the following soils are distinguished: solonchaks, xerorendzinas, protorendzinas, mull rendzinas, and various forms of "terra fusca" and "terra rossa." The authors conclude that there is at present some slight weathering, and consider the mineral basis of the soil ($SiO_2:R_2O_3 = 2.8$; pH 6.7 to 8.4) as a relic of the preceding soil formation, which took place under more humid conditions. They note an increased content of the fine sandy fraction, with quartz and feldspars predominating in its composition. The high content of feldspars of the plagioclase series shows the richness of these soils in "mineral reserves" and consequently, in the authors' opinion, their fairly high fertility.

In some red soils the authors observed a narrow $SiO_2:R_2O_3$ ratio which they associated with the relic character of these soils.

Albareda, Alexandre and Sanchez Calvo del Carmen [74] studied soils on the schistose shales of Toledo, Guadalajara and Segovia, Spain. They distinguish the following soil stypes: southern brown, xeroranker brown and bleached brown as well as two forms of fossil deposits relate red loams.

The authors present the following con sions: 1) illite predominates among the minerals in soils with a neutral or alkaline re tion; 2) both illite and kaolinite are found soils with a weakly acid reaction; 3) a high c tent of kaolinitic minerals is found in fossil soils.

Guerra and Monturiol [73]. The region Extremadura, Spain, is characterized by sligh rolling topography with an absolute elevation 300 m. The mean annual rainfall is 450 m falling during the winter. Summers are long, and hot. The soil-forming parent rocks are gr ites rich in feldspars and biotite, schist w quartzites, and sedimentary Miocene and Pl cene rocks. The influence of these rocks is dee stamped on the character of the soils.

Pararendzinas with a secondary accumulati of carbonates are formed on granites. Bro southern soils have developed on Pliocene san Red fossil soils (Barros, Rotlehm) with secon ary carbonate horizons are found on Siluri schists. Primitive soils were found on Low Pliocene clays with gravel.

Gracanin [89] investigated an area of Yug slavia extending from the coast (with 557 m rainfall, at a mean annual temperature 16.7°C.) to cold mountains with 3000 mm. rainfall at 6°C. Red soils (terra rossa) a found on Croatian karst under various fore associations of the "climax" type. Their evol tion and dynamics follow various trends, bu they have developed everywhere under the in fluence of degradation processes. Under eve green Mediterranean forests (*Quercetum ilius* these soils are relatively stable. Neverthele they grow rich in humus and change over "brown littoral forest soils." Under white beec forests, they undergo a process of brown ear formation, demonstrated by a tendency to th acidification of the reaction and a leaching cations from the adsorption complex. Very inten sive podzolization appears under beech forest and podzolized red soils are formed. Under pin forests, the strong tendency to podzolizatio results from the accumulation of acid raw humus

Inasmuch as red soils (terra rossa) are no formed under "climax" forests, but are degrade under them, they cannot be considered as pres ent-day zonal soils, but as fossil formations.

Popovatz and Spirescu [102]. Soils of south

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stern Rumania are formed on the re-deposited ducts of the weathering of Mesozoic lime- nes. The authors consider that the substances ntaining iron and giving rise to the red col- tion (rubefizierung) are found in larger ounts in those limestones which are in contact h biotite granites or with amphibole schists. e amount of iron-containing substances is atively increased during the weathering proc- . The present-day climate does not promote ddening (rubefizierung). Therefore the red s were formed earlier, under climatic and logical conditions conducive to reddening.

Mancini [63]. Investigations in Val di Lima, ly, were carried out in a region of widespread sozoic deposits, representing a series of lime- nes and calcareous rocks of various ages and mpositions. The absolute elevation is from) to 1300 m., which determines the differences climate and vegetation. Rainfall is from 204 1674 mm. and the average annual tempera- re is approximately 11° to 12°C. The natural getation is represented mainly by oak (*Quer- s pubescens*) with some Mediterranean ele- nts. Ash appears in the driest places. On steep pes up to 1000 m., there are associations with predominance of white beech. Beech is found dom and only in spots.

The author considers that the evolution of l formation on limestones proceeds thus: litho- (in foreign countries the name lithosol is en to scantily-developed soils on massive ks), protorendzina, rendzina, brown forest l (this last one is considered as "climax"). esent brown soils have developed on terra ssa.

Kanno [16]. In the southwestern part of pan along Pleistocene terraces and hills, soils e found with color ranging from yellow-orange reddish-brown. Mean annual temperature aches 14° to 16°C., rainfall is 1500 mm. dur- g the wet period in the warm season. Vegeta- n consists of evergreen broad-leaved forests th grasses in places where the forests have en cleared. Soils develop on various parent cks: granites, basalts, sandstones, shales, lime- nes, schistous shales and on terraces deposited ring the Pleistocene.

Horizon A has little colloidal fraction. This is t linked to podzolization, but rather to the echanical removal of fine particles. The mount of free iron oxide in horizon B reaches veral percent. The exchange capacity of the ils varies from 8 to 18 me. Thermal and X-ray analyses of the clay fraction showed the predominance of kaolin minerals—halloysite and hydrated halloysite and varying amounts of vermiculite and of crystalline hydrated iron oxides.

The author calls the soils red-yellow (not podzolized). He considers them as related to the red non-podzolized soils of China, to the red soils of India with a low pH, to the red earths of Australia and the Soviet Union, and also to some red-yellow podzolic soils of the United States. He emphasizes the distinction between the soils studied and the brown forest soils described by Robinson and Zigmond.

Bramao and Simonson [4] studied soils of the Rio Negro plains in Southern Brazil. Their absolute elevation is 945 m. The climate is moderately warm subtropical, with a rainfall of 1400 mm. and a mean annual temperature of 16.3°C. The authors consider that these soils have features of chernozem formation and of red-yellow podzolic soils. This combination indicates the need for distinguishing a new group of soils: "Rubrozem."

Kanno [17]. Soils on volcanic cinders of Japan were studied and divided into four subgroups: 1) brown type (on basaltic cinders); 2) "Onje" type (on cinders rich in volcanic glass); 3) brown light-yellowish type (on hornblende andesite cinders); 4) yellowish-brown type (on pyroxene andesite cinders). All these soils are distinguished by a strongly acid reaction and a very low cation saturation. Characteristic features are the abundant accumulation of humus (8 to 30% in horizon A), the eluviation of SiO_2 and of cations and the increase in the colloidal and the clay fractions in comparison to the fresh cinders. In the fraction smaller than 0.002 mm. in diameter he found predominance of allophanes, with varying amounts of gibbsite, iron hydroxides and kaolin minerals (usually hydrated halloysite). It is concluded that there are two stages of clay formation: the first, allophane; the second, halloysitic. The soils show no sign of podzolization or laterization, and differ from brown forest, black tropical and prairie soils. Therefore, Japanese cinder soils should be considered as a new great group of intrazonal soils.

Darby and Orchard [42] studied the soils of Natal (a province of the Union of South Africa), which Van der Merwe classified under the name of "lateritic yellow earths" and which are of agricultural importance in the districts investigated. The authors conclude that the climatic factor is the dominant one in the formation of the subtropical soils of Natal, since they possess common features independent of the parent rock on which they have developed.

Northcote [2]. Because of dissenting views about the applicability of the term "solonized" to some Australian soils (according to previous data of the author, the content of adsorbed sodium varies from 6 to 30% of the total exchangeable cations), the author proposes the new name of "Mallisol" (Eucalyptus soils).

The series of reports by soil scientists of Mediterranean countries is interesting in many respects. In the first place, independent of the Soviet school of soil scientists, they established the necessity of distinguishing between "southern brown forest soils" (cinnamon-brown forest, according to the classification of Soviet soil scientists) and the Central European brown forest type. In so doing they related the southern brown soils also to some soils not of forest origin but rather under "grassy vegetation" (see report 74) having an A horizon of neutral and a B horizon of alkaline reaction and abundant amounts of clay. That is, a soil such as we relate to the gray-cinnamon brown.

The tendency to segregate various soil formations which diverge from the collective type of "brown forest soils" is observed also by Yugoslav, Rumanian and Italian soil scientists. They record the occurrence in "Mediterranean brown forest soils" of intensive acidification and leaching, going so far as podzolization with the formation of iron-manganese concretions, even when they develop on limestones (Gracanin, Popovatz, Spirescu, Mancini). Mancini considers such soils as transitional to Central European brown forest soils.

Doubtless many of the intensively leached soils of the humid subtropical districts may be identified with the red earths and the yellow earths studied in the subtropical regions of the Soviet Union (the suggestion of Bramao and Simonson to segregate some soils as "Rubrozem"; Kanno's comparison of Japanese soils with those of India, Australia, Soviet Union, China and other countries).

Thus, the zonal types of the subtropical belt are: gray-cinnamon brown (they evidently also include the "Mallisols" of Northcote), the cinnamon-brown forest (typical and leached) and yellow earths and red earths. This series is giv in order of increasing humidity. Brown for soils are associated chiefly with mountain rang In our opinion they are subarctic soils.

As in other soil congresses, considerable atte tion was paid to questions concerning terra ros In the opinion of the majority of investigato the fundamental cause of the formation of the r clay substance in terra rossa is the iron-contai ing minerals present in limestones, which are on slightly stable in a warm, humid subtropical c mate. Since the present-day climate in a numb of the regions studied is relatively dry, their ter rossa is considered as a relic inherited from a pr vious warmer and more humid period.

A series of reports touched upon questions r lated to present-day soil evolution, mainly co sidered from the point of view of an increasin xeromorphism in soil formation.

Much of the information submitted to th congress clearly showed the preeminence of th bioclimatic factor in soil-formation.

Soil Formation in Warm Temperate and Cold Temperate Regions

Chiritza [103]. The author establishes a gen eral trend of soil development from brown for est to humus podzols in Rumania: On calcare ous rocks, from rendzinas to brown forest soils on siliceous parent rocks, the soils of the uppe zone are found at lower depths.

Fink [95]. In the humid western sections o Austria, leached soils (sols lessivés) have de veloped at altitudes over 200 m. In the drie eastern sections, brown forest soils are found but below 200 m. carbonate and non-carbonat chernozems are formed. The latter are found in islands and are retained from the time of the post-glacial optimum. The carbonate chernozems emerge after plowing as a result of erosion. A former climatic optimum during the post-glacial period is revealed by the existence, in deep layers, of "clay-enrichment zones" with a red color. The "humus zone" which lies above it is related to the existence of a colder period. Thus, present-day soils are linked to ancient landscapes.

Smolik [1]. In Czechoslovakia a distinction is made between present-day and ancient soil types. The present-day type includes the widespread podzols and podzolic, brown Central-European Ramann, chernozems, alluvial and mountain soils. Saline and peaty soils are not common.

mong the ancient fossil Pleistocene types are und polygonal structured soils, podzols, brown rest soils (often containing secondary carbnates), chernozems, terra rossa and laterites.

Stefanovits [51] pointed out that during podlization the clay minerals in horizon A_2 are stroyed faster than they are formed. Similar ta are obtained for solonetz, but with different mposition of the exchangeable cations. The tios of mobile Al and Fe to the exchange pacity in podzolic soils are broader than in own forest soils and solonetz; they are quite gligible in chernozems. (The determination of obile Al and Fe was conducted according to the ethod proposed by the author and published the journal "Agrochemistry and Pedology" grokém. es talaj), Budapest, Vol. IV, 1955.)

Manil [72], in his report "Dynamic Aspects of e Soil Profile," proposed to distinguish two sic elements in the formation of the soil profe. The first is manifest in the general morpholy of the profile (pedological profile) and depnds on the character of slowly proceeding matical variations; the second, on its ecologil properties (edaphic profile), brought about the influence of rapid changes in the plant ver.

Belgian soils are characterized by a degradan process. This is considered a (recent) tendcy proceeding under the influence of their olution, independent of its direction.

As an example of soil degradation under the fluence of vegetation, the author adduces the anges taking place in the brown leached soils Belgian oak forests when beeches are planted. nce beech possesses a superficial root system, the author's opinion, the middle part of the ofile (horizon B) ceases to be penetrated by ots and worms. This leads to the development podzolization; that is, to the formation of A_1, $_2$, B and C profiles, while under oak forests, own leached forest soils with profiles A, B and continue to exist.

An example of degradation under the influence climatic factors are iron podzols of the ancient liocene surfaces of Western Europe (paleodzols) formed during the Atlantic period. hese soils are at present under heath; deposion of products of the present illuvial-humic rocess is now occurring in them on ancient podlized soils. On the other hand, the same iron odzols (pedological profile) are transformed under the influence of oak-white beech forests into brown acid forest soils (edaphic profile).

The author considers that brown leached forest soils do not correspond to the Recent period, that their formation is related to a warm, humid Atlantic period and that their persistence in our age is due to the continuous action of artificial oak-white beech forests. Thus, the modern profile of these soils is edaphic.

Swindale and Jackson [37]. The determination of podzolization and laterization is usually carried out by excessively general concepts embracing a number of physical, chemical and biological phenomena. The authors studied two pedological processes: 1) soluviation, in which minerals are decomposed by solution and eluviation of the products—a process requiring the presence of moving water; 2) cheluviation, in which minerals are decomposed by chelation in solution and eluviation of the products in the presence of organic matter. The two processes proceed in a parallel but independent manner and may exist simultaneously. They may lead to the formation of podzolic and lateritic soils. Increasing soluviation leads to the following sequence in the transformation of the minerals: from feldspars to kaolinite to halloysite to gibbsite and to an increasing accumulation of iron oxides. There is leaching of the more soluble constituents and an accumulation of the more stable ones; latosol is formed. The predominance of cheluviation leads to the disintegration of the relatively stable minerals (kaolinite, halloysite, gibbsite), the removal of the free iron oxide and to the enrichment of the surface horizons with primary quartz: and podzolic soils are formed.

Duchaufour [60]. The report was devoted to the degradation of soils in the lower part of the Vosges mountains under coniferous forests on smooth (sandstone) slopes. It proceeds in four phases: brown forest acid, brown forest podzolized, podzolic, and iron-humic podzolic soils. During the brown forest acid soil phase, the organic matter rapidly decomposes but the migration of the humic complex does not take place because the iron is bound to the clay. During the brown podzolized soil phase, there is a lateral leaching along the slope of light-colored soluble fulvic acids and iron. During the podzolic phase, there is intensification of the descending currents of water and a concurrent eluviation of the complex compounds of fulvic acids and iron, which as a final result (fourth phase) leads to the formation of the ash-like A_2 horizon and of the black-brown B horizon, that is, of an iron-humic podzol.

Schelling [57]. In this report he develops concepts similar to those of the previous one. Many soils in the Netherlands are polygenetical, especially the podzols. The following serial development is observed: gray-brown podzolic to brown podzolic (humus-iron podzol), to podzol (humus podzol). In other words: B horizon, structural; B horizon, iron; B horizon, humic.

Bloomfield [3]. A column of ferruginous sand (quartz sand treated with iron oxide) was periodically treated with dilute aqueous leaf extract, leading to the formation of a profile reminiscent of a podzol profile (evidently illuvial-humic). The color of the column did not change on elution with water.

When the "podzol" thus prepared was treated with a dilute sodium carbonate solution, a lightening of the color of the sand in the column was observed. The solution thus obtained was brown and contained an appreciable amount of iron. In this way some correspondence between the behavior of organic substances in the soil and in the column was achieved. If, after treatment with the extract, the column was allowed to dry, a B horizon was formed at 1 to 2 cm. below the boundary between the dry and wet sand.

Wright and Levick [41]. The authors carried out an analogous experiment with a laboratory-model podzolization process in tubes. The soil was leached with a solution of EDTA (ethylenediaminetetraacetic acid) at a pH of 4.9 and a 5×10^{-4} molar concentration.

Crompton [25]. A distinction is made between three points of view about the formation of peaty-gleyed soils in Lancashire, England: 1) they are considered as fossil from the periglacial tundra stage; 2) they develop as the result of the swamping of podzol; and 3) as a consequence of the autodevelopment of swampy soils (point of view held by A. Muir). The latter is essentially that the strongly acid reaction of the peaty horizons saturated with water permits the migration of mobile compounds of iron in the reduced (ferrous) form into the well-drained subsoil. There they are oxidized to form iron-pans and ortstein interstratifications. In this the author agrees with A. Muir.

Raeside [107]. The present-day climate of New Zealand is subhumid, dry and cold, while the previous one was warmer and more humid. The vegetation varied accordingly from gras land to forest and back again to grassland.

The most characteristic feature of present-da yellow-gray soils is the formation of indurati horizons (hardpan) with vertical, blocky-pri matic peds. The soil texture is clay. The stru ture of the upper horizons is fine-granular, bu in the lower horizons it becomes more compa and coarse. Micromorphological studies of th induration horizon indicated the presence colloidal films enveloping the minerals. It is o this account that the minerals unite to form compact mass. The clay minerals identified wer illite, vermiculite, and montmorillonite with iro oxides. The author considers that these soils ar polygenetic and do not correspond to the present-day dry, cold climate. The formation o compact horizons is due to a previous cycl which was warmer and more humid.

A short review of the papers on soil genesi leads to the following conclusions:

1. In recent years great success has bee achieved abroad in the study of soil-formin processes.
2. This study is conducted, in general, on th principles of genetic pedology.
3. The study of soils is conducted through a wide application of a series of modern methods (thermal, X-ray, micromorphological). At the same time, there is no tendency to use biochemical methods for the study of humic substances to solve questions of soil genesis, or to use methods of permanent field experiments to study the dynamics of soil processes.
4. In modern foreign pedology there is wide interest in the elucidation of questions related to paleopedology and polygenesis, chiefly on the basis of the analysis of the causes leading to heterogeneity in the soil profile.

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Discussion

SOIL CLASSIFICATION OF ROSTOV REGION[1]

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A soils classification of Rostov region which is based to any considerable degree on the general genetic classification of soils of the USSR must reflect the genesis and fertility of the local soils. In working out such a classification we have attempted to use the ideas given at the All-Union Conference of Soil Scientists on nomenclature, taxonomy and classification of soils of the USSR.

For Rostov region we are using the general soil classification principles of Ivanova (8) and Rozov (10); the genetically classified, diagrammed series of soils (see Figure 1). These reflect the historical-genetic connection between individual soil types as stages of the development of soil formation. This outline is based on the teachings of V. V. Dokuchayev and V. R. Williams about soils and their evolution. We consider it the most practical. However, like Kovda (9), we do not consider such outlines obligatory in all cases.

In working out this soil classification for Rostov region we considered those proposed earlier by Zakharov (7) and Shul'ga (11), the taxonomic list of soils used by the Soil Group of the Land Use Administration and the wishes of the local production soil scientists as expressed in discussions of the proposed classification.

In our classification we were guided not by any single index, by rather by a complex of criteria. For example, we classified chernozem not by the amount of humus in the upper horizon, but by the following group of indices: the general makeup of the soil profile (soil habitus), thickness of the humus horizons (A + B), the amount of humus and the salt profile. If chernozems are classified only by the humus content of the upper horizon, as recommended by Durasov (6), then the best soils in the world—Kuban and Lower Don chernozems, which contain 4 to 6% humus—should be classified under
subtype "low-humus chernozems (southern
poor)." Here no consideration has been given
the fact that it is not only the humus of
upper horizons which determines the gene
and fertility characteristics of the soils but a
their thickness and structure, the conditions
their stratification, and so forth. But the prof
thickness and structure reflect the internal
of soils and it is natural to consider these ch
acteristics in addition to the humus content, n
only in the classification of chernozems but al
of other soils.

In accordance with Ivanova's idea (8) th
"the correct genetic classification of soils r
veals the laws of the genesis and geography
soils and is always geographogenetic," we en
phasized the elements of the soil zone and pro
ince—the geography—of the chernozem su
types. This is reflected in the soil designation
For example, the chernozems of the North Az
foreland constitute a provincial subtype of
more general group of chernozems, ubiquito
on the sloping plain of the Azov foreland. It
genetically a transitional phase between t
ordinary chernozems of the Eastern Europea
plain and the independent Caucasus-forelan
thick carbonate chernozems of the North Ca
casus. This is all the more important since th
Rostov regional soils are formed at a poin
where conditions of both the Eastern Europea
plain and the Caucasus foreland proper me
and overlap. This unique provincial soil cha
acteristic must be reflected in the soil class
fication. As Williams notes with complete just
fication (1), "The final goal of the enti
scientific system is to establish both the genes
of the complex of existing properties in th
group of bodies, substances or phenomena bei
studied and also the causative interrelations b
tween the evolutionary trends of the elemen
of this complex and of those of the surroundi
medium."

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[1] The classification was presented at a meeting of the Rostov Section of the All-Union Society of Soil Scientists in March, 1957.

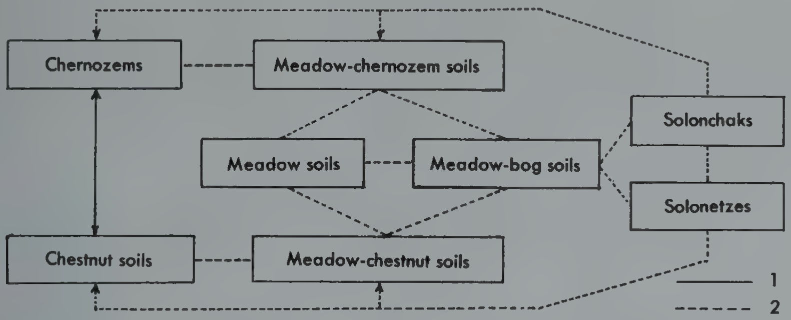

FIG. 1—Diagram of the genetic connections between types of soils in the Rostov region. 1—"Zonal" connections in the bioclimatic cycle of developement. 2—"Intrazonal" connections in the biogeomorphological cycle of developement.

To delineate the specific provincial character-tics of the Rostov regional soils caused by onditions of climate and facies, we decided to tain the old terms for local chernozems, North Azov foreland" and "Caucasus fore-nd." This is necessary and agrees with the revious terminology used by the local soil sci-nce specialists and agronomists. Also, the soil ience production personnel and agronomists ish to preserve the old terminology for local hernozems.

On the basis of the outline of the principles of oil evolution under Rostov regional conditions nd considering the wishes of local specialists, e have attempted to work out the classification see Table 1) using such taxonomic units as pe and subtype in conformity with the nomen-ature accepted at the 1957 plenary session of he Commission on Soil Classification, Academy f Sciences, USSR. We have used the following naller taxonomic units:

Species: a subdivision showing the degree of evelopment of soils within the subtype as udged by the thickness of the soils, the ac-umulation of humus, the extent of leaching and f solonetz and solonchak formation, and so orth.

Group: a subdivision determined by the ature of the soil-forming parent material classes).

Variety: a subdivision determined by the oil texture.

It should be noted that the chernozems were ivided according to their humus content into w-humus (less than 6% humus in the plow yer), medium-humus (6 to 9% humus) and ch (9% humus) and according to their thickness into thin (thickness of the humus-containing horizons (A + B) less than 40 cm.), medium thick (40 to 80 cm.), thick (80 to 120 cm.) and, finally, very thick (thickness of (A + B) more than 120 cm.). It is known that the thickness is a composite manifestation of all the elements of soil formation including the subsoil and, naturally, the thickness must be considered in the soil classification. Delineation of the generic subdivisions of the Rostov regional soils is now being studied.

In addition, depending on the character and extent of reclamation (cultivation), the soils are subdivided into tillage variants: old-plowland, strongly structured, weakly-structured, pulverulent, newly reclaimed, irrigated, gypsum-containing, virgin, idle land.

In subdividing chernozems into carbonate, slightly leached (slightly washed), medium leached (medium washed), and strongly leached (strongly washed) we have accepted (2, 3) the following grading scale:

1) carbonate chernozems, which effervesce under 10% HCl from the surface, or within the A horizon;

2) slightly leached chernozems, which do not effervesce with HCl in the A horizon, but do effervesce in horizon B_1 and deeper;

3) medium leached chernozems which do not effervesce in horizons A or B_1 but do effervesce in horizon B_2 and deeper;

4) strongly leached chernozems, that is, those which do not effervesce within the humus horizons (A + B) but in which effervescence is observed only in the parent material—C_1 or C_2.

The delineation of soils according to the extent of solonetzization was as follows:

TABLE 1

Soil classification of Rostov region

Profile No.	Index	Subtype	Species	Textural variety	Groups according to parent material (class)	Tillage variants
			I. Chernozem-type soils (Ch)			
1	Ch^{o}	Ordinary chernozems	Medium thick and thin humus. Carbonate, slightly and medium leached	Clay. Fine clay loam. Medium clay loam	On red- and yellow-brown clays, loess-like clay loams & schists	Old plow-land, with stron structure Old plow-land with wea structure Weakly, medium & strong eroded
2	Ch^{s}	Southern chernozems	Carbonate, eroded, solonetzized	Same	On loesses & clays. On schists	Old plow-land, pulverulen Newly reclaimed, irrigate
3	Ch^{NA}	North Azov foreland chernozems	Thick, medium thick. Carbonate and slightly leached	Clay. Fine clay loam	On yellow-brown clays. On loess-like clay loams	Same
4	Ch^{CF}	Caucasus foreland chernozems	Thick and medium thick. Carbonate, slightly and medium leached	Same	Same	Old plow-land, with stron & weak structure. Irr gated
5	Ch^{v}	Valley chernozems (transitional to meadow chernozem type)	Medium- and low-humus. Carbonate & leached. Solonchak, solonetzized & solodized	Clay. Fine clay loam. Medium clay loam	On yellow-brown clays, clay loams, and multiphase alluviums	Old plow-land with stron structure; old plow-lan with weak structure; irr gated
			II. Meadow-chernozem type soils (Ch_m)			
1	Ch_m^{l}	Leached meadow-chernozem	Medium humus, low humus. Thick and very thick. Slightly and medium leached	Clay. Fine clay loam	On clays and clay loams	Old plow-land. Newly reclaimed. Irrigated
2	Ch_m^{c}	Carbonate meadow-chernozem	Medium and low humus. Thick and very thick	Same	Same	Same
3	Ch_m^{sk}	Solonchak meadow-chernozem	Slight, medium and strong solonchak formation	Clay. Fine clay loam	On clays and clay loams, but salinized	Newly reclaimed. Irrigate
4	Ch_m^{sn}	Solonetzized meadow-chernozem	Weakly, medium and strongly solonetzized	Same	Same	Newly reclaimed. Gypsum-containing. Irrigated
5	Ch_m^{sd}	Solodized meadow-chernozem	Medium and low humus. Thick and superthick	Same	Same	Old land. Newly reclaimed Overgrown
			III. Chestnut-type soils (C)			
1	C_3	Dark chestnut soils	Carbonate. Slightly and medium solonetzized	Fine clay loam. Medium clay loam	On loesses and loess-like clay loams	Old plow-land with weak structure. Newly irrigated
2	C_2	Chestnut soils	Carbonate. Slightly, medium or strongly solonetzized	Same	Same	Old plow-land with weak structure. Newly irrigated. Virgin. Old idle land
3	C_1	Light chestnut soils	Same	Fine clay loam. Medium clay loam. Coarse clay loam	Same	Virgin. Old idle land. Newly plowed

TABLE 1—*Continued*

ro- le o.	Index	Subtype	Species	Textural variety	Groups according to parent material (class)	Tillage variants
IV. Meadow-chestnut type soils (C_m)						
1	C_m^l	Leached meadow-chestnut	Slightly, medium or strongly leached	Clay and fine clay loam	On loess-like clay parent material	Old plow-land with strong structure. Virgin
2	C_m^c	Carbonate meadow-chestnut	Strongly, weakly carbonate	Same	Same	Same
3	C_m^{sk}	Solonchak meadow-chestnut	Medium and strongly solonchak	Same	Same, but salinized	Newly reclaimed. Virgin
4	C_m^{sn}	Solonetzized meadow-chestnut	Slightly, medium or strongly solonetzized	Clay and fine clay loam	On loess-like clay parent material	Newly reclaimed. Virgin
5	C_m^{sd}	Solodized meadow-chestnut	Slightly, medium or strongly solodized	Same	Same	Same
V. Flood-plain meadow type soils (M)						
1	M^l	Meadow leached	Medium humus and rich. Slightly and medium leached	Clay. Clay loam. Loamy-sandy	Multiphase alluviums	Old plow-land. Newly reclaimed. Virgin
2	M^c	Meadow carbonate	Medium humus and rich	Same	Same	Same
3	M^{sk}	Meadow solonchak	Slightly, medium and strongly solonchak	Clay. Clay loam	Same, but salinized	Newly reclaimed. Virgin
4	M^{sn}	Meadow solonetzized	Slightly, medium or strongly solonetzized	Same	Same	Old plow-land. Gypsum-containing. Virgin
5	M^{sd}	Meadow solodized	Slightly, medium or strongly solodized	Same	Same	Old plow-land. Newly reclaimed
6	A_m	Slightly developed alluvial-meadow soils	Slightly humified. Humified	Clay loam. Clay sandy loam. Sandy	On alluviums. On buried soils	
VI. Meadow-bog type soils (B_m)						
1	B_m^l	Meadow-bog leached	Slightly and medium leached. Thick and medium thick	Clay, fine clay loam, medium clay loam and coarse clay loam	On clays, clay loams and alluvial deposits	—
2	B_m^c	Meadow-bog carbonate	Thick. Medium thick	Same	Same	—
3	B_m^{sk}	Meadow-bog solonchak	Slightly or strongly solonchak	Same	Same	—
4	B_m^{sn}	Meadow-bog solonetzized	Slightly solonetzized Strongly solonetzized	Clay, fine clay loam, medium clay loam and coarse clay loam	On clays, clay loams and alluvial deposits	—
5	B_m^{sd}	Meadow-bog solodized		Same	Same	—

TABLE 1.—*Continued*

Profile No.	Index	Subtype	Species	Textural variety	Groups according to parent material (class)	Tillage variants
			VII. Solonchaks (S_k)			
1	S_k^{chm}	Meadow-chernozem solonchak	Puff. Wet	Clay. Fine clay loam	On salinized clays and clay loams	—
2	S_k^{mk}	Meadow-chestnut solonchak	Crust. Puff. Wet	Same	On salinized parent material	—
3	S_k^{m}	Meadow solonchak	Same	Same	Same	—
4	S_k^{bm}	Meadow-bog solonchak	Puff. Wet	Different textures	On clays and alluvial deposits	—
			VIII. Solonetzes (S_n)			
1	S_n^{ch}	Chernozem solonetz	Medium columnar. Deep columnar	Clay. Fine clay loam	On salinized clays and clay loams	Newly reclaimed. Gypsu containing
2	S_n^{mch}	Meadow-chernozem solonetz	Same	Same	Same	Same
3	S_n^{k}	Chestnut solonetz	Crust. Medium columnar. Deep columnar	Same	Same	Same
4	S_n^{mk}	Meadow-chestnut solonetz	Medium columnar. Deep columnar	Same	Same	Same
5	S_n^{m}	Meadow solonetz	Same	Same	Same	Same
6	S_n^{bm}	Meadow-bog solonetz	Same	Same	Same	Same

1) weakly solonetzized (exchangeable sodium 3 to 5% of the adsorption capacity);

2) medium solonetzized (sodium 5 to 10%);

3) strongly solonetzized (sodium 10 to 15%);

4) solonetz (sodium constitutes more than 15% of the adsorption capacity).

The delineation of soils by texture was carried out by the generally accepted classification of N. A. Kachinskiy.

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Methods

RAPID DETERMINATION OF SOIL MOISTURE BY THE HYDRIDE METHOD

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A rapid and simple determination of soil moisture is of very great practical importance. This is clear from the fact that in all regions with artificial irrigation the most important aspect to be regulated is the duration of watering, which depends on the moisture content of the soil. With the usual method for determining moisture by the drying method it is very difficult to get an idea of the actual moisture content available to plants and thus to know the wilting point of any soil. At the same time it is just these data which are of practical interest.

The drying method, as is well known, gives the loss in weight of soil kept at 100° to 105°C. This way, in addition to the hygroscopic moisture the water of crystallization of many compounds is also determined, for example gypsum, montmorillonite and other clays and so forth. Finally, the water content of all substances which lose their more firmly bound water at 100° to 105°C. is determined. Thus, water determination by the drying method does not give a correct idea of hygroscopic moisture.

The hydride method proposed by Yelitsur (3) to determine the water of crystallization by heating in the presence of pyridine or dioxane (3, 4, 5, 6) may be used successfully to determine loosely bound water (held by a mechanical or physicochemical bond). The hydride method is based on the reaction between calcium hydride and water:

$$CaH_2 + 2H_2O \rightarrow Ca(OH)_2 + 2H_2.$$

During the reaction, hydrogen is given off very rapidly and its volume may be used to determine precisely the amount of water which has reacted.

This method for determining soil moisture was developed as a result of checks on different methods of removing water from soils (5, 6). These showed that the introduction of moisture removing media (dioxane, pyridine) is no necessary, since this causes a slower reaction The best results are obtained when a weighed soil sample is placed in one arm of a Landolt tube while granular or powdered calcium hydride is placed in the other (see Fig. 1). After connecting the Landolt tube through a rubber tube to a gas burette (100 ml. or larger), the contents of the tube are mixed as carefully as possible. This causes the immediate release of hydrogen and the reaction is finished in 5 to 7 minutes. However, the burette should not be read for 10 to 15 minutes since a considerable amount of heat is liberated during the reaction and the tube must be cooled to room temperature with water. About a tenfold excess of calcium hydride should be used.

The percentage of soil moisture is calculated by the formula

$$\frac{V\cdot p\cdot 18\cdot 100}{T\cdot R\cdot \text{sample weight}},$$

in which V = observed volume of hydrogen in milliliters; P = observed barometric pressure; 18 = the molecular weight of water; 100 = multiplier for giving the result in percent; T = observed absolute temperature (273 + t); R = the universal gas constant, 62,400; $18\cdot 100/R$ = a constant, 0.02885. Substituting it in the given formula, we obtain the final formula for calculating the percentage of soil moisture:

$$\frac{V\cdot p\cdot 0\cdot 02885}{T\cdot \text{sample weight}}$$

The Table gives the results of parallel determinations of moisture by the hydride method in the cold, with heating, and by the method of drying to constant weight at 100° to 105°.

Using the hydride method with heating, from the time the soil sample and the calcium hydride ere mixed, the Landolt tube was heated in a oiling water bath until the end of hydrogen beration and expansion. For cooling, the tube as immersed in water at room temperature until he gas reached a constant volume.

The following conclusions may be drawn from he data in Table 1:

1. The loosely bound water in the soil (held y a mechanical and physicochemical bond) is etermined by the hydride method in the cold. or this reason the results of such determintions are lower than the results obtained by rying at 100° to 105°. The latter determines ot only the hygroscopic water but also the ater of crystallization of many compounds. n some cases, results of moisture determinaons by the hydride method in the cold coincide ith those obtained by drying at 100° to 105°. his shows the absence from the sample of ater of crystallization which is not determined y the hydride method in the cold, but which is moved by heating.

2. The results of moisture determinations by e hydride method with heating agree with the sults of determinations made by drying at 00° to 105°.

Interesting data were obtained in determining e moisture in gypsum. The determination of its water content by the drying method was carried out at a temperature above 150°, resulting in the removal from the gypsum of both molecules of water of crystallization, so that the result obtained (25.6%) includes both the hygroscopic water and the water of crystallization. If the theoretical content of water of crystallization, 20.9%, is subtracted from the 25.6%, the hygroscopic water fraction amounts to 4.7%. The calculated content of hygroscopic water in the gypsum agrees with the figures established by the hydride method—4.69 and 4.45%.

A. G. Yelitsur (3) gives a number of advantages in using calcium hydride rather than calcium carbide, which is sometimes used for the determination of hygroscopic moisture: a) calcium hydride is more reactive to water vapor than is calcium carbide; b) when calcium hydride is used the volume of hydrogen given off is twice as great as that of the acetylene when

TABLE 1

Moisture determination

Designation of sample	Water content in percent					
	Drying method		Hydride method			
			In the cold		With heating	
	I	II	I	II	I	II
River sand	0.44	0.44	0.39	0.42		
Sand washed with HCl	0.038	0.032	0.038	0.032	0.036	0.032
Slightly podzolized soil:						
A_P 0 to 20 cm.	5.17	5.11	4.23	4.18		
same	5.14	5.01	4.64	4.36	5.47	5.24
same	6.56		5.40	5.29	6.25	6.05
Slightly podzolized soil:						
A_B 23 to 33 cm.	5.22	5.24	4.17	4.17	5.10	5.11
same	6.50	6.33	5.24	5.24	6.17	6.02
same	5.84	5.93	5.06	5.00	5.95	5.72
Soil samples from pot experiments with oats:						
a) River sand	0.27	0.31	0.27	0.25	0.35	0.32
b) Slightly podzolized clay loam soil from the plow layer	5.43	5.45	5.05	4.90	5.77	5.64
c) Garden soil	13.85		12.33	12.31	13.21	13.15
Gypsum	25.6	25.6	3.58	4.05	4.69	4.45
Mixture of 9.9 gm. of sand with 0.1 gm. of gypsum	0.23	0.24	0.023	0.025	0.24	0.23
Field pit, 0 to 10 cm.	3.65		3.41			
Same, 18 to 28 cm.	3.31		3.23			
Same, 40 to 50 cm.	3.34		3.17		3.26	
Same, 80 to 90 cm.	3.98		2.85		3.92	

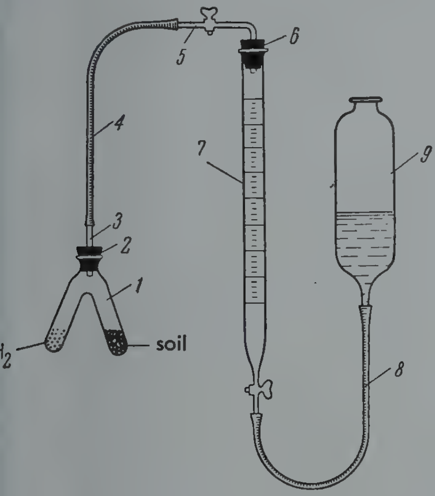

FIG. 1.—Apparatus for the rapid determination soil moisture by the hydride method. 1—Lanolt tube; 2—rubber stopper; 3—glass tube; 4—bber tube; 5—glass stopcock; 6—rubber stopr; 7—burette for measuring the volume of drogen; 8—rubber tube; 9—leveling vessel.

calcium carbide is used; c) hydrogen is practically insoluble in water and has the greatest specific volume of all gases.

For this reason the accuracy of water determinations made with calcium hydride is greater than those made with calcium carbide. It must also be noted that the velocity of the reaction between calcium hydride and water vapor is considerably greater than that between calcium carbide and water vapor.

Conclusions

1. The hydride gas-volumetric method makes it possible both in the laboratory and in the field to determine the true content of hygroscopic moisture in the soil by the use of very simple apparatus.
2. Moisture determinations by the hydride method with heating and in the cold make possible the differential determination of the loosely bound water (held by a mechanical and physicochemical bond) and of the more firmly chemically bound water, that which is held chemically (water of crystallization, zeolitic water and so forth).
3. The results of moisture determinations by drying usually agree with the results obtained by the gas-volumetric method when the latter is carried out by heating on a water bath.
4. A great advantage of the hydride method for determining soil moisture is its rapidity. The operation of mixing the soil sample with the calcium hydride and cooling (even when ther is previous heating) does not require more tha 20 minutes.

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USE OF SOIL TEXTURE TO EVALUATE NATURAL FERTILITY AND BASIC SOIL PROPERTIES FOR AGRONOMIC PURPOSES

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WE EVALUATED the physical and physico-mechanical properties of soils without reference to the soil zones. Although it is obvious that these properties must be better, for example, in chernozems than in podzolic or chestnut soils, the differences among them may be materially changed and reduced by agricultural methods.

It is also impossible to give a general evaluation of physical properties applicable to all soils and plants. The soil requirements of plants (for example of trees like the eucalyptus and white acacia, of bushes like tea and grape, of grain crops such as water-loving rice and drought-resistant millet) all are different. However, most of the field and garden crops have much in common in their soil "requirements." To assist soil scientists and agricultural production workers we suggest our scale of approximate evaluations of the physical soil properties. It is the result of many years of studying these properties in the field and in the laboratory; we also include an approximate scale for the intrazonal evaluation of the natural fertility of soils according to their texture.

Note: It is useful to recall that for non-humified horizons the product of the apparent specific gravity of the soil multiplied by the moisture capacity by weight is almost constant. Thus, if one of the two values is known, we can calculate the other (when these two characteristics apply to some horizon). For example, in horizon A_2 of a sod-podzolic clay loamy soil the apparent specific gravity of the soil is 1.4; the moisture capacity is 25%; in horizon B_2 of the same soil apparent specific gravity of the soil is 1.7; the moisture capacity of B_2 is equal to $\frac{(1.4)\ (25)}{1.7}$, or 20.6%.

The *maximum hygroscopic coefficient* of the soil varies from tenths of a percent (in sands) to 10 to 20% in clay loams and clays. It increases in proportion to the content of the clay fraction (particles <0.001 mm. in diameter) and of humus. In peat it may reach 50% and higher. In the soil profile it is manifested least in the eluvial horizons (for example, in the A_2 horizon of podzolic soils) and most in the illuvial horizons (for example, in the B_1 horizon of solonetzes or the B_2 horizon of podzolic soils).

Depending on the type and horizon of the soil and also on the nature of the vegetation and its stage of development, the *wilting coefficient* varies from 1.2 to 2.5 times the maximum hygroscopic coefficient of a given soil or of its horizons. More often it is about 1.5 times the maximum hygroscopic coefficient.

Moisture not available to plants ("dead water storage in the soil") for most cultivated plants is equal to the maximum hygroscopic coefficient alone. For halophytes, which have a high osmotic pressure in the juice of the root cells, the amount of unavailable water decreases to <0.8 of the maximum hygroscopic coefficient.

In offering our evaluation scales by zones for the physical properties of soils and for the soil texture, we do not consider them perfected. We hope that workers in the fields of soil physics and mechanics will introduce their own refinements and will continue work in this direction.

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TABLE 1

Evaluation of the basic physical properties of soils

Properties	Amounts	Evaluation	Remarks
Apparent specific gravity of soil diameter or bulk density if expressed in gm./cm.^{3}, kg./l. or metric tons per hectare	<1	Soil fluffy or rich in organic matter, e.g. the sod of field and forest soils	For sandy field soils values fro 1.3 to 1.5 are characteristic. I the sod horizon of garden an forest soils the value may de crease to 1.2 to 1.3.
	1.0 to 1.1	Typical values for cultivated land	
	1.2	Soil compacted	
	1.3 to 1.4	Soil strongly compacted	
	1.4 to 1.6	Typical values for horizons below A_p in various soils	
	1.6 to 1.8	Compacted illuvial horizons, mostly of podzolic soils and solods	
Specific gravity of the solid phase of the soil ("real" specific gravity in the old terminology)	2.5 to 2.65	Typical values for the plow layer of medium-humus soil	Specific gravity of: quartz = 2.5 orthoclase = 2.54 to 2.57 kaolinite = 2.60 to 2.65 muscovite = 2.76 to 3.00 biotite = 2.70 to 3.10 plagioclase = 2.67 to 2.74 hornblende and augite = 2.9 t 3.4 limonite = 3.5 to 3.95 organic compounds of the soil = 1.2 to 1.4 to 1.7
	<2.5	Soil rich in organic matter	
	>2.7	Soil rich in iron compounds or heavy minerals such as biotite, muscovite, hornblende, augite	
Total pore space for clay and clay loam soils, %	55 to 65	Cultivated plow layer	Pore space of cultivated sand soils is 45 to 50%. Aeration pores in a cultivated soi should amount to not less tha 25 to 30% of the total pore space
	>70	Fluffy soil	
	50 to 55	Satisfactory for plow layer	
	<50	Unsatisfactory for plow layer of clay and clay loam soils	
	25 to 40	Characteristic of compacted illuvial horizons	
Pore space of aggregate, %	>50	Best	
	45 to 50	Good	
	40 to 45	Satisfactory	
	<40	Unsatisfactory	
	<30	Extremely bad	
Total moisture capacity[a]	40 to 50	Best	Cultivated sandy soils—in th plow layer—20 to 25%; variou sands, 3 to 20%. For cultivate fields those sands are suitabl which have a moisture capacit of not less than 10%, for forest not less than 3 to 5%.
	30 to 40	Good	
	25 to 30	Satisfactory	
	<25	Unsatisfactory for fine textured soils	
Permeability to water of the soil at a water pressure head on the soil surface (H) = 5 cm. at a temperature of 10°C.; expressed in terms of mm. of a water column absorbed during the first hour.	>1000	Disastrous	The more uniform the permeability at the field surface and th more constant the permeabilit is in time, the better its quality. On unirrigated tracts continuous observations should be carried out for not less than 3 hours, on irrigated tracts, for not less than 6 hours. The first case is based on the possible duration of a strong rain, the second on the average duration of irrigating the field.
	1000 to 500	Too high	
	500 to 100 evened out over entire area	Best	
	70 to 100	Good	
	30 to 70	Satisfactory	
	<30	Unsatisfactory	
Stickiness at a total soil moisture capacity (by Kachinskiy's method) in gm./cm.^{2}		Soil:	
	>15	max. sticky	
	5 to 15	very sticky	
	2 to 5	medium sticky	
	0.5 to 2	slightly sticky	
	0.1 to 0.5	friable	

TABLE 1—*Continued*

Properties	Amounts	Evaluation	Remarks
Resistance to penetration (hardness by Kachinskiy method) in kg./cm.^{2}	>100	Indurated	When the shaft is plunged into the soil 6 cm. and less
	50 to 100	Extremely hard	
	30 to 50	Hard	
	20 to 30	Fairly hard	
	10 to 20	Fairly loose	
	<10	Loose	
Relative soil moisture,[b] %	90 to 70	Optimal for most field and garden crops	
	>90	Excessive	
	70 to 50	Satisfactory	
	<50	Insufficient	
Relative moisture when tilling stubble fields with tractor in low gear, %	60 to 70	Optimal	On tracts having a pan, plowing is possible at about 10% higher relative moisture than on soft plowland. In solonetz soil varieties the optimum moisture for tillage is about 10% less. Loamy sand and sandy soils allow plowing beginning with a relative moisture content of 100% and below. Plowing of clay loams and clays with the tractor in intermediate and high gear can begin when the relative moisture is higher by 5 to 10% than can tillage in low gear.
	50 to 60	Satisfactory	
	70 to 80		
	>80	Excessive—soil turns to mud	
	<50	Insufficient—soil turns to dust, plowland is cloddy	

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[a] By total moisture capacity we mean the maximum amount of water in the soil as a percentage by weight which can be retained by the soil after a prolonged rain or artificial watering and after drainage f the free gravitational water from the saturated horizons or strata.

[b] Absolute moisture as a percentage of the total moisture capacity.

TABLE 2

Approximate site quality ratings of different soils according to their textures[a]

Zones	Subzones	Soils by texture and scale rating						
		Clay	Fine clay loam	Medium clay loam	Coarse clay loam	Sandy loam	Firm, very fine granular sand	Friable, medium granular sand
Podzolic	Gley-podzolic soils	4	6	8	10	8	5	3
	Podzolic soils proper	5	6	8	10	7	5	3
	Sod-podzolic soils	6	7	10	8	6	4	2
Gray forest	For all subzones	8	10	9	7	6	4	2
Chernozem	Rich, thick and ordinary chernozems	10	9	8	6	4	3	1
	Southern (thin) chernozems and the Azov foreland and Caucasus foreland chernozem provinces	9	10	8	7	5	3	1
Chestnut	Dark-chestnut	8	10	9	7	6	3	1
	Chestnut and light-chestnut soils	7	9	10	8	6	3	1
Brown	For all subzones	7	8	10	7	5	2	1
Sierozems	For all subzones	8	10	9	7	4	3	1
Krasnozems, zheltozems and zheltozem-podzolic soils	For krasnozems and zheltozems	10	9	7	6	4	—	—
	For zheltozem-podzolic soils	8	9	10	9	6	4	2

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[a] Site quality ratings were arrived at by considering the nutrient reserves in the soil, the water, air nd heat relations and the degree of difficulty encountered in cultivating for grains. (The evaluation is iven for each soil zone in the European part of the USSR on a 10-point rating scale.)

PRINCIPLES OF THE AGROCHEMICAL CHARACTERIZATION OF SOILS

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A MEASURE of the progressive, socially useful function of agricultural chemistry in the national economy is the degree to which the introduction of chemical methods in agriculture helps to industrialize it. The growing requirements of the national economy necessitate raising the level of agrochemical research both in the field of general agrochemistry and in its specialized branches.

One of the most important general problems of agricultural chemistry is the development of scientific bases for planning production, allocation and use of fertilizer. Usually this problem is solved by a system of field experiments, carried out over a number of years. The more intensive these are, the more accurate and reliable are the results. The experiments are usually accompanied by a certain complex of soil-agrochemical research. This is a costly and lengthy procedure which we are, nevertheless, compelled to use. This generally accepted method is straightforward, but essentially empirical. Meanwhile, at the current level of our knowledge (considering the data accumulated both in field experiments and soil-agrochemical research) we need a means of scientific prognosis of the action of fertilizers on various types and varieties of soil; that is, we need a gradual transition from an empirical to a scientific method of investigation through the agrochemical characterization of soils in the broad sense.

What is usually understood by agrochemical characterization of soils is the conjunction of the results of an organized assemblage of soil-agrochemical analyses, as, for example, determination of pH, adsorption capacity, carbonate content, humus content and soluble forms of nitrogen, phosphorus and potassium. In the ideal case these data are correlated with the results of a field experiment and with respect to a given, specific locality. At the present time we must broaden the agrochemical characterization by changing the subjective of soil investigation.

What requirements must be set forth for the agrochemical characterization of soils on the new level, and what purpose and content mu these studies have?

Primarily, we must widen the scope of t questions asked of agrochemical characterizati to achieve the most complete evaluation of bo the potential and the actual fertility of t given soil type. We must study the working r lations of such soil under various climatic co ditions and determine the trend of agronomicall important soil processes (including the princip microbiological processes) and their materi factors. We must determine the conditions f the regulation or modification of these process by artificial means, the use of various fertilizer and methods of improvement and modificatio of the microbiological regime. Then an appraisal must be made both of the growth crops in a given soil at a given stage of cro rotation and of the reactions to fertilizers an other improvement methods.

If such studies were made on the most important soil types we could characterize the so completely that the data obtained could b extended to all similar soils. By extrapolatic and interpolation, we could predict the prope ties of some intermediate soil varieties eve without detailed studies merely by introducin details of the specified crop, its sequence in th crop rotation, and so forth. It is then possib to combine in a single group a series of so varieties, plan agrochemical improvement common to all of them and differentiate within single variety the various conditions related t irrigation, crop rotation and so forth which sometimes develop more emphatically than do the di ferences among soil types.

We still do not know the exact limits of all th problems relevant to a study which will produc a complete agrochemical soil characterizatio Nevertheless, two major stages in the work ca be seen: a) the accumulation of facts by usin various investigation methods; b) the selectio of a minimum set of indices for agrochemica soil characterization, and also of the simples and cheapest methods of soil-agrochemistr inspection suitable for mass use.

The solution of this problem is the most general and important task of the agricultural chemists of the Soviet Union. It can be accomplished by the efforts of all the Republic organizations coordinated by the V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR.

The Laboratory of Agricultural Chemistry, Academy of Sciences, Armenian SSR began work on this problem in 1956. At the present time a plan has been adopted for the agrochemical characterization of the Armenian soils. An account of this plan will enable us to evaluate its contribution to this problem and to clarify the problem further by an exchange of opinions.

Work on the agrochemical characterization of Armenian soils is currently divided as follows:

1. Compilation of a brief sketch of the soil cover of the principle agricultural regions of the Republic and providing a basis for deciding which of the chief types of soils in the zonal profile should be studied. We believe that this part of the work, which determines the efficient scope of all the studies, is very important. At present our work concerns 16 soil objectives, among which are included carbonate and noncarbonate varieties of brown, light chestnut, chestnut, dark chestnut, former forest (converted to steppe), and chernozem soils. It must be noted that the objectives so far selected will be supplemented on the basis of recently developed and confirmed findings on the agricultural zones of the Armenian SSR.

2. Characterization of the most important indices of the chemical composition of soils and their nutrient content. This includes the determination of humus, carbonate content, degree of salinization or saturation with cations, pH, and the N, and K content, both total and in easily soluble form.

3. Determination of the physical properties of soils which are most important for the best use of applied fertilizers (specific gravity, bulk density, moisture capacity, water permeability, consistence, hygroscopicity, structure, and so forth).

4. Physicochemical characterization of soils (study of the pH relations, oxidation-reduction processes, composition of soil solutions and of water extracts).

5. General microbiological characterization of soils (composition by groups of microflora, observations on how fertilizers act on nodule formers in legumes and so forth).

6. Enzymatic activity of soils (study of the activity of catalase, invertase, and urease).

7. Radioactivity of soils, to establish its relation to the conditions of plant nutrition.

8. Determination of the content of micronutrients and the efficiency of fertilizers containing them.

9. Use of chemical analysis of plants in the field to test diagnosis methods.

10. Characterization of the efficacy of mineral and organic fertilizers in the soils under study. The survey in this division will be compiled on the basis both of data from this Laboratory and also of the existing literature concerning results of field and pot experiments and will take into account the data from agrochemical analyses.

11. The most difficult and responsible phase of the work will be the establishment of correlational connections among the findings of the different divisions, without which further predictions on the action of fertilizers on all the soils of Armenia are impossible.

12. As a result of all these studies, and with the utilization of a soil map of the Republic, a soil-agrochemical map of the Armenian SSR should be compiled to make possible state planning for the requirement, allocation, and use of fertilizers.

We have made the scope of this work wider than usual, as is apparent from the list of the divisions of the agrochemical characterization of soils.

On the basis of D. N. Pryanishikov's idea that "...a single instrument can be successfully used by different specialties," we decided to draw upon the most diverse methods of related specialties, in the interests of the most complete agrochemical soil characterization. In this connection a number of problems arise which are not specific to agricultural chemistry, but may contribute to a manifold agrochemical soil investigation.

1. The determination of the texture and structure and certain other indices of the physical properties enables us to clarify a number of agrochemical processes. These include: the movement of fertilizers in soils and their adsorptive capacity with respect to plant nutrients oxidation-reduction processes, microbiological activity, and the water relations of soils.

TABLE 1

Enzyme activity in different soils[a]

Soil	Catalase O_2 per cm.³/gm. dry soil/min.	Invertase in mg. of invert sugar/gm. soil/24 hrs.	Urease in mg. N/gm. dry soil/24 hrs.
Leached mountain mineral chernozem (Loriisk breeding farm, hayfield)	3.7 (2.1)	54.6	7.8
Dark chestnut, noncarbonate, fine clay loam (Martuninsk district, plowed field)	7.6 (4.2)	21.6	1.4
Light chestnut, slightly carbonate, fine clay loam (Ashtarynsk region, plowed field)	13.4 (9.7)	10.1	0.53
Brown irrigated-cultivated, carbonate clay loam (Oktemberyansk, cotton)	12.2 (8.3)	6.0	0.50

[a] The figures in parentheses show the catalase activity in variants with sterilized soil.

2. This general microbiologic characterization aims to clarify the tendencies of those microbial processes which act directly on soil nutrient relations. Thus, just one determination of the development of Azatobacter in several soils showed a marked difference among them. While we observed great activity of this useful microorganism in the soils of the Ararat plain (they are present there in tens of millions per gram), in the chernozem soils of the Loriis plateau, Aparan, the sapropelic formations the Sevan basin, in a number of other soils it altogether absent.

TABLE 2

Influence of fertilizers on invertase and urea activity in soil

Enzyme	Without fertilizers	$N_{100}P_{100}K_{60}$	Manure, 40 metric t.	Manu 40 me ric t. - P_{300}
Invertase (mg. of invert sugar/gm. dry soil/24 hrs.)	8.4	9.6	11.6	12.
Urease (mg. N/gm. dry soil/24 hrs.)	0.56	0.76	1.21	1.

Also, of great interest to agricultural chemistr is the study of the influence of fertilizers i changing the soil microflora, the growth of nodule-forming bacteria and so forth.

3. An entirely new division of our investigatior is the determination of the enzymatic activity o soils. Investigations in this area have been starte by V. F. Kuprevich at the Belorussian Academy of Sciences, in Germany, in Czechsolovakia and for two years they have been carried out i our Laboratory by A. Sh. Galstyan, Cand. Agr Sc.

Because the problem is such a new one we wil present a few examples to help evaluate th agrochemical significance of the results obtained

We determined the activity of catalase, invertase, and urease by the methods recommended by Kuprevich (1951) and Gofman (1953) Samples for the analyses were obtained over th course of the whole growing period. The soil wa

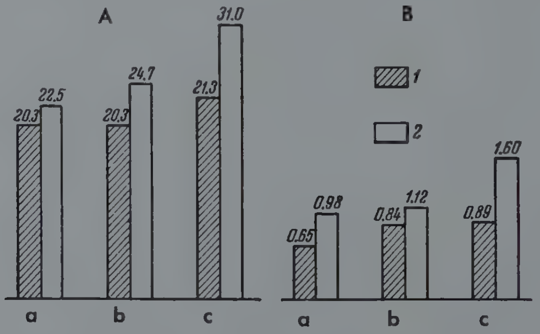

FIG. 1.—Invertase and urease activity

A—Invertase (in mg. of invert sugar/g. of soil); B—Urease (in mg. of N/g. of soil); a—barley; b—cotton; c—lucerne. 1—Outside the rhizosphere; 2—within the rhizosphere.

cleared of roots, dried, and screened through a sieve with 1 mm. diameter opening.

To determine catalase activity, 1 gm. of such soil was placed in a 100 ml. glass jar, to which 0.5 gm. of chalk and 5 ml. of 3% H_2O_2 was added. Soil which had been first sterilized in dry heat at 180° served as the control. Catalase activity was expressed in milliliters of molecular oxygen given off in the course of 1 minute at 18 to 20°C. per gm. of soil.

Invertase activity was determined by the following method: batches of soil (5 gm.) were placed in 100 ml flasks; to this was added 25 ml. of a 5% solution of substrate + buffer with a pH of 4.9, and five drops of toluene. The flasks were corked, shaken, and kept in a constant-temperature oven of 30°C. for 24 hours, after which their contents were filtered off and the content of reducing sugar in the filtrate was determined according to the method of Bertran. As controls, experiments were set up with substrate without soil and with soil sterilized in dry heat at 180°C. for 3 hours. Invertase activity was expressed in milligrams of invert sugar formed per 24 hours per gm. of dry soil.

For the determination of urease activity, 5 gm. soil samples were placed in 50 ml. flasks, and mixed with 15 ml. of phosphate buffer (pH 6.7) and 0.5 ml. of toluene. After 15 minutes 10 ml. of a 10% solution of urea was added; the flasks were closed with cork stoppers, agitated, and placed in a constant-temperature over at 37° to 38°C. for 48 hours, after which the contents of the flasks were transferred to round-bottom flasks and distillation of ammonia was carried out with MgO. The control was substrate without soil and with sterile soil. Urease activity was expressed in milligrams of nitrogen per gm. of dry soil per 24 hours.

The data, presented in Tables 1 and 2, indicate substantial differences in the activities of the enzymes in various soils and make possible the evaluation of the effective fertility of soil from a new standpoint. Moreover, the action of extracellular enzymes is a specific one; it shows the concentration of the biochemical processes. Thus, in soils with high inversion capacity, low catalase activity appears, and vice versa.

The Fig. 1 shows the results of a comparative determination of invertase and urease activity outside and inside the rhizosphere of various plants grown in a brown irrigated-cultivated soil (Echmaadzin). They are evidence of an increased rate of biochemical processes in the rhizosphere, leading to the formation of substances easily assimilated by plants.

The examples show that in this new research field at the junction of agricultural chemistry and biochemistry, we can expect valuable results which will contribute to our knowledge of the effective fertility of soils.

4. Great interest certainly attaches to the wholly unexplored field of the radioactivity of the soils of Armenia and also to the study of their micronutrient content.

Complex investigations in the agrochemical characterization of soils are necessary, not only for scientifically-based planning for fertilizer demand and allocation, but also for working out promising tendencies for efficient use of soils.

It must be noted that to supplements these Armenian studies work has begun on the compilation of small-scale soil-agrochemical maps of collective farms. This is conducted by the "Bureau of Fertilizer, Soil Science, and Soil Preservation Service" recently created in the Main Administration of Land Organization, Ministry of Agriculture, Armenian SSR. Yet both in Armenia and in the other republics, there is the danger of methodological error of two kinds: the work either degenerates into a mere mechanical soil survey, or into "soil-less" descriptions of a plan for the use of fertilizers. Such digressions may obscure the true nature of the problem.

Investigations on the agrochemical characterization of soils planned by the Laboratory of Agricultural Chemistry, Academy of Sciences, Armenian SSR are also contributing to the production of more purposeful small-scale soil-agrochemical mapping of collective-farm lands.

The workers' collective of the Laboratory of Agricultural Chemistry, Academy of Sciences, Armenian SSR recognizes that the solution of the problem presented above is extremely complicated and difficult, and that the effectiveness of some divisions is not sufficiently evident. Therefore, an annual redefinition of the volume and content of the work, based on results obtained, is envisioned.

It seems necessary to us to call a special business meeting to coordinate the projects on this problem, with a view to solving it on an all-Union scale.

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PHYSICAL NATURE OF THE SECOND CRITICAL POINT O CURVES OF THE DRYING RATE OF SOILS (CLAYS)

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As a hydrophile disperse system, the soil is a typical colloidal capillary-porous body. In addition to the solid dispersed phase, the soil always contains water (moisture) which plays a very important role in its life and which affects its fertility. Numerous experimental investigations fully justify the view that the water in hydrophilic dispersed systems is bound to the disperse phase in various ways and is not uniform in its physical properties. The different moisture states in soil dispersed systems determine their structural-mechanical and other properties.

The process of moisture removal or migration within the colloidal capillary-porous body is accompanied by destruction of its bond with the material or it is caused by the predominance of some kind of bond on which a certain amount of energy is expended in both cases. It is therefore more practical to use the energy principle as a basis for physically correct classification of the forms of moisture bonds, since this principle is characterized by the intensity of bond energy. This is the principle on which Rebinder's diagram (1) is constructed, and it includes all the different forms of moisture bonds: chemical, physicochemical and physicomechanical.

An investigation of the drying process might clarify the quantity of moisture held by a physicochemical bond (bound water). It is known that Kossovich (4) in his investigation of soil water evaporation has established the periodicity of the drying process.

The outward sign of the drying process is the sample's loss of weight with the passage of time. For this reason observation of the kinetics and dynamics of the drying process is simply a matter of recording weight loss over a certain period of time under given drying conditions.

The drying process may be illustrated most graphically by using curves of the drying rate (the graphic relation between the drying rate, $dW/d\tau$, and the moisture content by weight, W) on which it is usually possible to distinguish the critical points and its abrupt changes. The critical points of the curves are determined both by parameters of the conditions of drying (t° = temperature, ϕ = relative moisture, v = rate of movement the drying agent, air), and also by the structu of the substance and the forms of the moistu bond with the substance. Papers by Lykov (showed the relation to the parameters of the dr ing conditions of the critical points. However, th relation between the forms of moisture bonds an the critical points of drying rate curves has no yet been adequately clarified. Only Lykov's theoretical work makes reference to the variety forms of moisture bonds with the substance a the critical points.

The present article is devoted to an exper mental clarification of the physical nature of th second critical point of the drying rate curves colloidal capillary-porous substances, especiall clays.

The investigation of the course of the dryin process in clays was carried out in a specially constructed circulating desiccator consisting of small rectangular chamber 400 × 280 × 280 mm with double walls (Fig. 1). Electric heaters ar placed in the space between the walls of the chamber. Each electric heater consists of two winding of nichrome wire (R_1 = 250 ohms and R_2 = 8 ohms) connected in parallel and evenly woun on asbestos sheets.

The desired temperature is maintained in the chamber by a thermostat acting through a relay, **2**.

Measurements of fluctuations are made by the deviation of the illuminated spot of a galvanometer connected to a copper-constantan thermocouple, the cold junction of which is placed in Dewar flask and kept at a constant temperature fluctuations are also read from the thermometer **8**, placed in the chamber of the desiccator. The maximum deviation from the given temperature during the entire experiment (5 to 6 hours) ±0.2°C. Thus, it can be assumed that the thermostat keeps the drying conditions constant with respect to one of the parameters—the temperature of the drying agent. The required constancy of the second parameter of the drying conditions —the relative humidity of the air within the desiccator—is provided by anhydrous, chemically

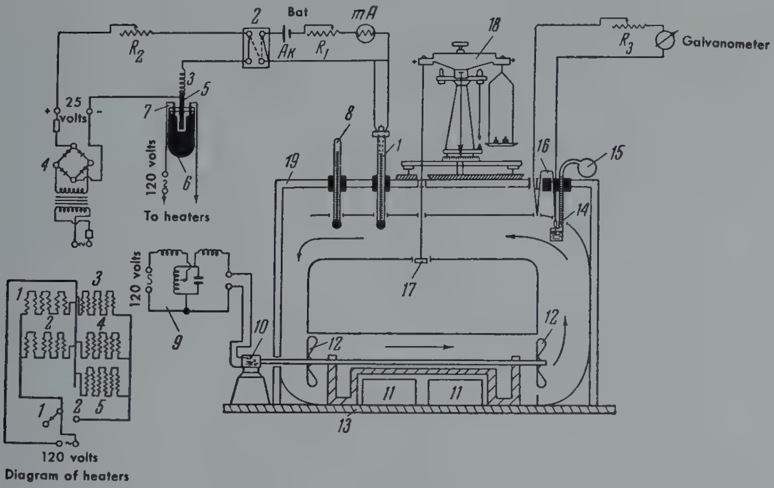

FIG. 1.—Drying apparatus. 1)—Thermostat; 2)—relay; 3)—coil; 4)—copper-oxide rectifier; 5)—iron armature; 6)—glass reservoir with mercury; 7)—platinum contacts; 8)—check thermometer; 9)—ferro-resonance voltage regulator; 10)—electric motor; 11)—dessicant containers; 12)—axial fans; 13)—frame for attaching blower axis; 14)—reservoir with distilled water; 15)—bulb for filling reservoir with water; 16)—thermocouple psychrometer; 17)—pan for sample to be dried; 18)—scale; 19)—space within double wall.

ure calcium chloride or a solution of sulfuric id of a definite concentration, **11**.

The stability of the relative humidity of the r is checked with a psychrometer. However, istead of the usual wet and dry bulb thermome- rs, use is made of a thermocouple **16**, which in- eases the accuracy of the measurements and ecreases the amount of space in the chamber ccupied by apparatus. The hot junction of the sychrometer thermocouple is in direct contact ith the air. The cold junction is wrapped in a nall piece of fine linen or cotton cloth (from a andard sample) which is placed in a reservoir ith distilled water. The reservoir is filled with ater through a fine metal tube by means of a ubber bulb. The double porcelain tubes of the ot and cold junctions of the thermocouples are rought out through rubber stoppers. The scale f the mirror galvanometer is previously gradu- ted in percent of relative humidity of the air for ny convenient temperatures of the dry junction nd for the temperature difference between the ry and wet junctions of the thermocouples at air rculation rates of 0.5 and 1 m./sec.

The humidity of the air in the chamber is meas- red at the beginning of the experiment (during e constant drying rate) and at the end of the xperiment (during the period of internal diffu- on) when the drying process is known to be independent of the humidity of the air. Because the relative humidity of the air in the desiccator with an accuracy of 0.5% is maintained, we consider that the second parameter of the drying conditions—the relative humidity of the drying agent —is also constant.

To provide air circulation in the dessicator, it is divided by metal sheets into an upper and a lower half. In the upper half a specially constructed tube is installed to concentrate the current of air and make it uniform and even. An axial blower with two propellors is installed as a mechanical impeller for the circulation of the air in the lower half of the chamber above the containers of calcium chloride or sulfuric acid and in the tube above the sample to be dried. The blower is driven by a small (100 watt) model MU-100 electric motor installed outside the chamber. The connection between the motor shaft and the shaft on which the blower propellors are fastened by collars is effected through a rubber flange coupling by means of which undesirable vibrations are kept out of the chamber. Voltage for the motor is taken from the building electric mains through a Siemens and Halske ferroresonance voltage regulator and through two rheostats, one with high and one with low resistance. When there is a voltage fluctuation at the input of 15% of 220 volts, the voltage fluctuation at the output of the regulator will amount to not more than 1% of 220 volts, that is, 2.2 volts. Previously, an ASO-3 vane anemometer is used to establish the relation between the velocity of the air current in the chamber and the voltage required by the motor. To record the loss in weight of the sample to be dried a laboratory scale is installed on a base on the top of the chamber but not connected with it. One pan of the scales is replaced by a long metallic shaft. At the end of the shaft a metal frame is fastened. It carries an ebonite pan in which the moist sample is placed. The pan is arranged in such a way that the samples, as they lose weight, may rise freely, without any contact, in a special opening in the lower base of the tube. The length of the shaft is chosen in such a manner that only the surface of the sample, from which the evaporation of the moisture takes place, projects into the air current, and not the whole sample. Such an arrangement for weighing minimizes swinging of the sample in the air current in the tube. Weighing is carried out to an accuracy of 0.010 g. without stopping the blower.

The clay samples are prepared for the drying experiment as follows: The clay is carefully mixed with distilled water to a given moisture content and formed into the shape of small cylinders in a split mold 5.2 cm. in diameter. The clay cylinders, dried at 20° and 2 to 3 mm. thick, are placed in the ebonite pan. Their lateral surfaces are covered with several layers of a moisture- and heat-insulating mixture of celloidin and collodion.

In all experiments, the experimental samples of clay are moistened to an initial absolute moisture content of about 35%; variations in the initial absolute moisture content are, as a rule, no higher than ±1%. The volume weight of the moistene clay samples in all the experiments should b about 2000 kg. per m^3. The clay samples thus pre pared are placed in the desiccator after the give drying conditions have reached a constant leve

Weight loss is recorded as follows: Initially the scale is roughly balanced with not quit enough weight in the pan; then, with a stopwatc having two hands, note is made of the time whe the pointer of the balance goes through the zer point of the scale: at this instant the sum of th weights on the pan is equal to the weight of th sample and its pan. Then the scale is again roughl balanced with the weights short by 0.2 to 0.4 gm and so forth. At the moment the balance time i noted, a note is also made of the temperature an relative humidity in the desiccator. At the en of the experiment the sample is brought to oven dry weight at 110° in a constant-temperature oven. The temperature in the desiccator is 20°.

Curves of the drying rate of clays are shown in Figs. 2 and 3. In experiments to determine the physical nature of the second critical point of the curves of the drying rate of clay, the variable parameter of the drying conditions was the relative humidity (ϕ). The temperature ($t°$) and the velocity of the air current (v) remained constant. It is known that the air current velocity during a period of decreasing drying rate hardly affects the value of W_{cr_2} (relative humidity at the second critical point), since the drying process here is limited by the conductivity of moisture.

Regardless of the different values of ϕ at which the drying process takes place, W_{cr_2} for the same clay was about the same. Differences in the values of W_{cr_2} did not amount to more than 0.3%. For-

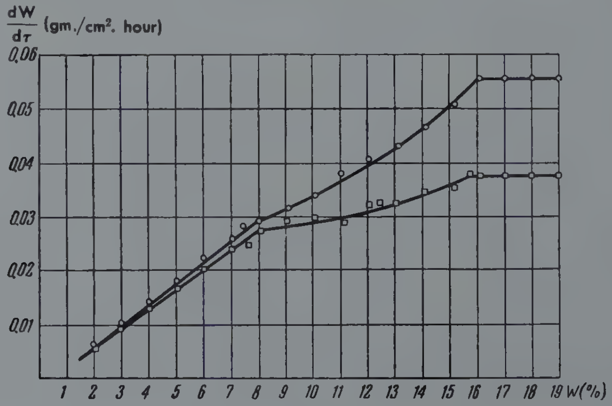

FIG. 2.—Curves of the drying rate of Poltava clay

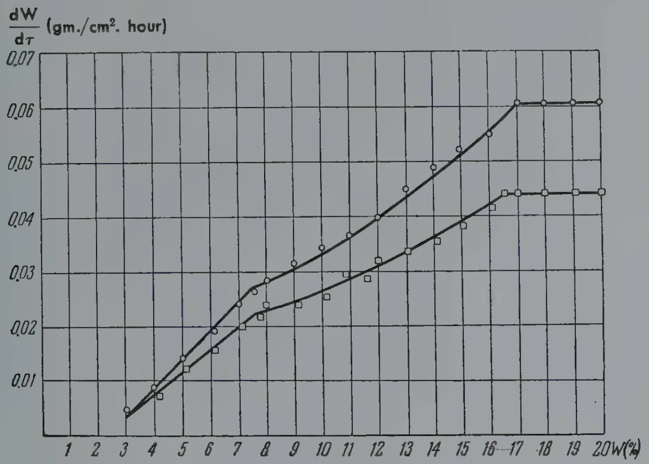

FIG. 3.—Curves of the drying rate of Chasov Yar clay

oltava clay W_{cr_2} is 7.5% and for Chasov Yar ay it is 8%.

Good reproducibility was obtained when running curves of the drying rates, both for the ablute values of the drying rates and for the values W_{cr_2}. The thickness of the samples to be dried as 2 to 3 mm. At such a sample thickness the rface moisture (U_n) may be considered as approximately equal to the integral moisture (W) the sample (that is, the moisture gradient may considered as zero). This was confirmed experientally.

The physical nature of the second critical point the drying rate curves of clays was clarified by mparing the values of W_{cr_2} with the amounts bound water in clays as obtained by refracmetry and interferometry by the method of umanskiy et al. (2), and also by tensiometric alyses and by measuring the effect of the moisre content of moistened clays on their dielectric efficient (ε) (4). All these values were obtained a temperature of 20°C. The comparisons are own in Table 1.

The agreement of the values of W_{cr_2} on drying in samples with values of bound water in clay tained by other reliable methods confirms ykov's hypothesis that W_{cr_2} marks the boundy point of bound water. We can then consider at the curves of the drying rates of thin samples n serve as a method for determining the nounts of bound water in colloidal capillaryrous substances, particularly clays.

The amounts of bound water as determined by urves of the drying rate may be somewhat too high. This may be explained partly by the fact that when $W = W_{cr_2}$, U_n probably remains somewhat less than the average integral moisture even when drying samples only 2 to 3 mm. thick. It is also partly explained by the fact that when the method of the heat of wetting is used, the amount of bound water is determined as a monomolecular layer (2). The values for the drying rate in the zone of internal diffusion during the period when the drying rate is decreasing should be affected by the polymolecular layers of the type investigated by Deryagin (1) or by the loosely bound water (in the terminology of Rode (6)) which has decreased mobility.

TABLE 1
Amount of bound water in percent

Substance	By refractometry	By interferometry	By tensiometric analysis	Singular point on curve of $\varepsilon = f(W)$	U_n at $W = W_{cr_2}$
Poltava clay	6.92	6.57	6 to 7	5.2	7.5
Chasov Yar clay	7.73	7.01	7 to 7.5	5.6	8.0

Conclusions

1. A comparison of the experimental data on the drying of thin samples of clays, of the effect of their moisture content on the dielectric coefficient of moistened clays, and of the amount of bound water as determined refractometrically and interferometrically, showed that the second critical moisture of samples being dried established the borderline for bound water.

2. Curves of the drying rate of thin samples may serve as a method for determining the amount of bound water in clays.

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REFINEMENT OF THE GEYSLER-MAKSIMYUK CALCIMETER

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TO SPEED UP the determinations of the carbon dioxide of soil carbonates, G. P. Maksimyuk 1) suggested a method based on the use of a omewhat modified Geysler calcimeter. As is nown, the Geysler-Maksimyuk method makes possible to determine the carbon dioxide con- nt quickly and with adequate accuracy. How- ver, for determinations on a large scale many lcimeters are required, each one of which must e washed and dried before each determination. his slows down the analytical work.

We suggest a certain refinement for the Geys- r-Maksimyuk calcimeter making it possible to ispense with that inconvenience to some extent. diagram of our suggested calcimeter is shown Fig. 1. It consists of a 10 ml. separatory nnel, A, a Meyslya trap, B, a shortened rubber opper, C, and a 50 ml. flask, D. The trap and paratory funnel are mounted in the stopper, C, hich is fitted tightly into the neck of the flask. he assembly consisting of parts A, B and C will e referred to as the working part of the calcime- r.

The determination of carbon dioxide is as fol- ws: Nine ml. of 18% HCl solution is poured to the separatory funnel and 1 ml. of concen- ated H_2SO_4 is poured into the Meyslya trap. he openings of the funnel and the trap are care- lly wiped clean with filter paper and closed with ortened rubber stoppers. Then the entire cal- meter is carefully wiped off with filter paper, lowed to stand for three minutes in the balance om, and then weighed. After this the working art of the calcimeter is disconnected from the ask. Then from 1 to 5 g. of soil (depending on e expected content of carbonate carbon diox- le) is placed on the bottom of the flask by means a test tube. The calcimeter is assembled and eighed again. (During the first and second eighings the hydrochloric acid must not be al- wed to wet the stopper closing the funnel, as is would distort the results of the analysis.) ext, the stopcock on the funnel is opened cau- ously and the hydrochloric acid is allowed to ter the flask drop by drop; for this, it is neces- ry to open the tops of the funnel and the trap ightly, but the stoppers should not be removed entirely from the openings. When all the hydrochloric acid has passed from the funnel into the flask, the stopcock is closed and the opening of the funnel is firmly closed with the stopper. When bubbles of CO_2 are no longer given off, the calcimeter is placed on a heated asbestos plate and warmed to 60° to 70°C. until drops of condensed water appear on the walls of the flask. After this the apparatus is removed from the plate and the opening of the trap is closed with stopper E, which is connected through glass and rubber tubing to a calcium chloride drying column. The partial vacuum arising in the flask as a result of its cooling is dissipated by allowing air to enter through the drying column and trap. During this, branch G of the T-tube must be opened. When the vacuum has been dissipated as determined by the cessation of bubbling in the trap, it is disconnected from the drying column, stoppered, and the calcimeter is completely cooled. To hasten dissipation of the vacuum and cooling of the apparatus it is convenient to use the "cooling nest" E, a diagram of which is shown in Fig. 1. The shape of the nest conforms to the shape of the flask. The cooling of the calcimeter flask placed in the nest is hastened by circulating tap water in the housing of the nest. After the calcimeter

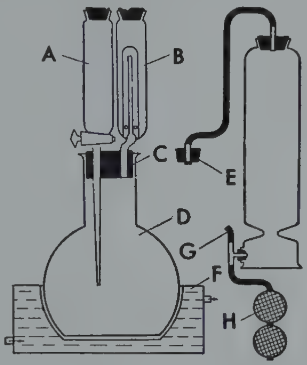

FIG. 1.—Diagram of calcimeter. A—Separatory funnel; B—Meyslya trap; C—shortened rubber stopper; D—flask; E—stopper; F—cooling nest; G—branch of T-tube; H—rubber bulb.

TABLE 1
Content of carbonate carbon dioxide (as percentage of dry soil)

Sample number	Knop's method			By calcimeter		
	Parallel determinations		Average	Parallel determinations		Average
1	0.18	0.21	0.19	0.14	0.19	0.17
2	9.60	9.56	9.58	9.53	9.50	9.52
3	8.15	8.10	8.13	8.09	8.18	8.14
4	6.88	6.81	6.85	6.80	6.80	6.80

has cooled the carbon dioxide contained in it is carefully removed by the use of the rubber bulb, H, which is connected through the T-tube with the drying column. In this process, branch G of the T-tube is pinched shut, the funnel opening is stoppered and the stopper of the trap is opened slightly. After the carbon dioxide has been removed by pumping air through for 5 minutes, the openings of the trap and the funnel are both stoppered. The apparatus is carefully wiped off with filter paper and, after standing 5 minutes in the balance room, it is weighed. The difference in weight of the calcimeter before and after the removal of CO_2 corresponds to the amount c carbonate carbon dioxide contained in this so sample. To carry out the next determination th working part of the calcimeter must be carefull wiped off with filter paper, the flask replaced an the determination described above repeated. Wit enough flasks and two calcimeter working parts 23 to 25 determinations can be made in a workin day. The sulfuric acid in the Meyslya trap shoul be changed after every four determinations. Sinc all the flasks have different weights, it is informative to number them on weighing. The table show comparative data from determinations of carbonate carbon dioxide made by using our calcimeeter and by using Knop's method on the same soil samples. The results of the determinations show quite satisfactory agreement.

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HE AGRONOMIC IMPORTANCE OF SOIL DENSITY

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'N THE literature there are quite a few data . showing that soil compaction (rolling) in- eases in agricultural crop harvests. However, ; Yu. I. Sinel'nikov[1] states, there has not yet een a clear answer to the question: at what de- ee of soil density are the optimum conditions r growth and development of grain crops? We ould therefore consider his suggestion that it is ecessary to set up broad experiments for study- g the plant requirements for optimal density nd for developing corresponding agricultural ethods. Further, in our opinion, no causes have ntil now been revealed for the increase or de- ease in plant harvests when soil density changes.

Until recently soil compacting (rolling) action ı the growth, development and harvest of crops as explained chiefly by a change in the soil oisture relations. Essentially, Sinel'nikov is also this opinion. His article consists of two parts: the first he considers the effect of rolling on the il moisture relations and in the second the ef- ct of soil density on the growth, development nd harvest of crops. Here he implies that the st growth and harvest increase is dependent on e conservation of moisture when soil density creases.

Sinel'nikov, supporting Kolyasev's theory of ifferential moisture (4–10), also supports his wn views by referring to investigators who ex- lained the favorable action of compaction on the rowth and harvest of plants, from a viewpoint ther than the conservation of soil moisture by lling (12, 13, 17, 18, 19). Further, he does not efer to papers which reach different conclusions garding the effect of rolling on soil moisture lations and on harvest (2, 3, 14, 15 and others). inel'nikov also gives regrettably little attention his investigation methods, although such de- riptions are needed in papers of this kind.

Thus, Sinel'nikov asserts that rolling assures ı increase in soil moisture and consequently in e harvest of grain and industrial crops. We ink that his treatment of the role of compaction (rolling) is incomplete and insufficiently convincing. Many data show that rolling does not conserve of soil moisture, rather, it decreases the storage. Experience also shows that compaction does not always increase the harvest; it may be higher with a decrease in the total soil moisture if the moisture distribution becomes more favorable for plants. It should be noted that Sinel'nikov confuses the concept of "water relations of the soil" with "water relations of plants." His article proves the favorable action of rolling on the soil moisture relations, but concludes that rolling improves the water relations of plants.

This paper gives the results of our experiments in rolling the soil under early grain crops. The experiments were carried out from 1951 to 1954 on the fields of the experimental support farm, V. V. Dokuchayev Institute of Agriculture, Central Chernozem Belt. The soil consists of ordinary chernozem. Its capillary moisture capacity is 54 to 58%, and its wilting coefficient 15 to 17% of oven-dry weight.

In addition to the purely field-type experiments, joint laboratory-field experiments were set up. In 1951 and 1952 the latter included a study of the effect of compaction on moisture evaporation, using Popov model 5 evaporator-lysimeters. In parallel experiments soil moisture was determined on fallow areas with similar tillage and on sowed plots the harvest was determined. In these experiments a compacted pan was produced by Kolyasev's method (4).

Field experiments were carried out with spring wheat (with inverted and without inverted layers of perennial grasses), with oats and barley. The area of the experimental plots was 0.6 to 1 hectare with two replications and 1.5 to 12 hectares without replication. Rolling was done by a tractor-drawn ZKK-6 ring roller carrying a 500 kg. weight (giving a total pressure of 2.6 kg. per cm.^{2}) which increased the soil bulk density by about 20% at a depth of 5 to 10 cm. Studies were made of changes in physical soil properties (bulk density, pore space, aggregation), the dynamics of soil moisture and of the elements of the nutrient regime, the distribution by depth of the seeds sown, extent of infestation of the sowings by weeds, and so forth. Soil moisture was determined gravimetrically both under the plants and on the specially laid out fallow areas with three replications of the borings in 1951 and five replications in 1952 and 1953. Harvest from each plot was measured by weighing the grain collected by the combine.

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[1] Sinel'nikov, Yu. I. 1954. Ob agronomicheskom nachenii pochvennoy plotnosti (The agronomic nportance of soil density). Pochvovedeniye No.).

During this research the meteorological conditions varied: in 1951 the first half of the growing period was favorable for grain crops (soil well-moistened, moderate temperatures), but the soil dried out in the second half; in 1952 the precipitation was comparatively uniform; the spring of 1953 was very wet but the summer (at the time when the spikes were ripening) was dry; in the spring of 1954 the soil moisture storage was negligible, in the middle of the growing period conditions were more or less favorable but thereafter both the soil and the air dried out.

The laboratory experiments included the following treatments: 1. Control: top 10 cm. layer friable, remainder of soil in natural condition (fall-plowed). 2. With a dense zone: top 5 cm. layer friable with a compacted zone at a depth of 5 to 10 cm.

The observations on evaporation began at the sowing of early grain crops and continued for 41 days in 1951 and for 62 days in 1952. The inside cylinders of the evaporators were weighed daily and changed from the lysimetric position to t evaporometric, and vice versa.

TABLE 1

Total weight of water evaporated from a surface of 500 cm.², grams

Treatment	April 9–May 19, 1951	April 30–June 30, 1952
Control	1373	4731
With dense zone	1616	5009

TABLE 2

Average soil moisture as percent of weight of oven-dry sample

Treatment	April 13–May 19, 1951	April 30–July 31, 1952
At a depth of 5 cm.		
Control	31.7	28.3
With dense zone	34.3	30.4
In the layer between 5 and 40 cm.		
Control	38.8	34.8
With dense zone	37.0	33.1

The results[2] of these investigations are show in Table 1.

These data show that in the 1951 experime 17.7% more moisture evaporated in the presen of a compacted zone than on the control area In 1952 the observation period was increased t two months. However, in this experiment, to the total amount of water evaporating on the co trol area was less. In any case, on the basis these data the conclusion must not be drawn tha compaction conserved moisture better. Th dense zone had no advantages over a friable laye in preventing evaporation.

Considering that the Popov evaporator-lysim ters with which these observations were mad have substantial shortcomings, we turn to th results of the investigations on soil moisture car ried out in parallel on fallow areas having simila tillage. The soil moisture was determined ever 4 to 6 days in 1951 and every 15 to 16 days i 1952. Table 2 shows the results in the form o moisture averages for the observation periods.

Table 2 shows that in the treatment with th compacted zone the soil moisture at a depth of cm. was higher and in the layer between 5 an 40 cm. it was lower than on the control. Observations in 1951 and 1952 for three months (unti the end of July) gave similar results.

Thus, the observations on soil moisture showe the same regular pattern as did the observations on evaporation: compaction did not provide better moisture conservation and, further, the loss of water in this case became even greater. At the same time, compaction increased the moisture content of the top soil layer (to a depth of 5 cm.). In the laboratory-field experiments the barley harvest was measured. The average yield of grain for two years on the control was 110.1 g. and in the treatment with compaction, 121.9 g., or 10.6% more, from 100 plants. Consequently, regardless of the decrease in total soil moisture the plant crop increased with compaction.

In considering the results of the field experiments, we will not cite here all our data on the effect of rolling on the physical properties of soil (bulk density, pore space, aggregation), on the nutrient relations, on weed infestation of the owings, and so forth. We will concentrate on the asic question of this discussion: the effect of olling on the moisture relations.

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[2] Because of lack of space the data on evaporation and soil moisture must be given as total or average values instead of in dynamic form.

Table 3 shows the average soil moisture conent by layers in the experiments.[3] It is seen that n both treatments, rolling increased the moisture n the upper (seed-depth) soil layer, but the total oisture storage in the plow layer and the suboil in the treatments with rolling were lower, ot higher, than on controls.

There were similar results in experiments on ess fertile land. Table 4 shows that both under lants and on (clean) fallow the soil moisture in ne plow layer and the subsoil was lower with olling than on the control. At the same time the pper 5 cm. layer of soil on rolled plots had a igher moisture content. Thus, for example, in 952 the soil moisture at a depth of 5 cm. on falow plots was higher, on the average, by 1.6% n the experiments with spring wheat and by .5% in those with oats, calculated on the basis f oven-dry soil.

Thus, our experiments did not establish the dvantage of rolling to conserve soil moisture. he persistent increase in soil moisture from rollng in the field experiments of some investigators 5, 6, 7, 9, 20) may be explained by the fact that ne comparison was made between controls and racts which had been plowed, replowed or deeply osened in the spring. If a comparison is made etween 1) the soil moisture on plots tilled to a epth of 15 to 20 cm. and 2) the soil moisture on lots which have also been loosened and then olled and the soil moisture determined in the 20 25 cm. layer, it is understandable if the moisure storage are higher in the latter. This can be lly explained by the theory of capillary moisure movement. In developing practical recomendations for regulating spring crop moisture lations (or winter crops on fallow) in the zone fluctuating or insufficient moisture, it is not orrect to compare the moisture in two such eatments as "friable" and "compact" soil. The omparison should be made between soil which ad been loosened down to seed depth and soil hich had also been compacted.

In such a comparison the differential moisture eory that compaction—rolling—brings about tention of moisture *as soon as the soil moisture falls below the field capacity* is not confirmed under the conditions on the Kamennaya steppe. In defending this theory Sinel'nikov, to be consistent, should have recommended rolling instead of loosening fallow fields in spring and summer to conserve moisture. Thus, for example, in the Ukraine or the Central Chernozem Belt the soil moisture in fall-plowed fallow (except in spring or after a heavy rain) is below the field moisture.

We will not consider the effect of compaction on moisture relations at a content below the so-called maximum molecular moisture capacity and around the wilting coefficient. We do not intend to dispute the opinion that rolling at some low soil moisture content makes water retention possible. But can this idea explain the favorable effect of rolling on increased early grain crop harvest if there is a similar soil moisture content in the plow layer and, even more important, in the root zone? An example, is the Kamennaya steppe, where this occurs during only the second half of the growing season or before the grain ripens, while the favorable effect of rolling on

TABLE 3

Soil moisture as percent of oven-dry sample

Treatment	1951 (under plants		1952 (on fallow (areas)		1953 (on fallow areas)
	Soil layer in cm.				
	0–5	5–40	0–5	5–40	0–50
Harrowing	24.7	30.9	33.6	35.5	32.5
Harrowing & rolling	26.9	29.6	36.3	35.1	30.8
Harrowing & cultivation	23.8	31.4	33.4	35.4	31.7
Harrowing & cultivation & rolling	25.2	30.0	34.0	34.3	31.0

TABLE 4

Average soil moisture as percent of oven-dry sample

Treatment	May 16–July 8, 1952 Depth 0–40 cm.		May 14–July 24, 1953 Depth 0–50 cm.	
	Spring wheat	Oats	Spring wheat	Oats
Under plants:				
Control	30.2	25.4	27.0	24.1
Rolling	28.1	24.4	24.0	23.4
On fallow areas:				
Control	33.9	33.1	33.1	31.0
Rolling	32.2	32.3	30.5	29.4

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[3] The soil moisture was determined nine times om April 11 to June 29, 1951; three times from ay 10 to July 7, 1952; and five times from May to July 18, 1953.

plants develops from the first days of the growing season.

In our experiments rolling primarily made possible a more even distribution in depth of the sown seeds. Thus, for example, in 1951 56% of the seeds were located at a depth between 3 and 5 cm. on the control plots, but on rolled plots 84% of the seeds were at that depth; in 1952 the figures were 54% and 79%, respectively. Rolling assured earlier and more continuous appearance of shoots. Thus, on the ninth day after sowing the spring wheat plants on one square meter were counted: on the control there were 416, on rolled plots, 530; in 1953 ten days after sowing there were only half as many shoots on the control and so forth. Rolling exerted a favorable effect on the rooting of plants. For example in the 1951 experiment, on May 17,100 wheat plants had 153 nodal roots in the control area, but 255 in the rolled area; in the 1953 experiment the corresponding figures on May 26 were 35 and 46.

From the very beginning of vegetation, the quicker and more uniform appearance of shoots and better secondary rooting made possible an improvement in the growth and development of the vegetative and reproductive organs of plants. In most experiments this improvement led to larger harvests.

Table 5, giving the spring wheat harvest in the layer experiments, shows that, except in 1954, rolling increased the harvest of grain from spring wheat. In 1954, regardless of the high densi and better growth and development of the veg tative and reproductive organs, the spring whe harvest on the rolled area (12 hectares) w somewhat lower.

TABLE 5
Grain harvest of spring wheat in centners per hectare

Treatment	1951	1952	1953	1954
Early spring harrowing	14.6	14.0	9.0	7.4
Same + rolling	—	15.5	11.0	6.7
Early spring harrowing + cultivating	15.9	14.5	11.2	—
Same + rolling	16.8	16.9	12.2	—

TABLE 6
Grain harvest of early grain crops in centners per hectare

Treatment	Spring wheat			Oats		Barley	
	1951	1953	1955	1952	1955	1954	1955
Control	13.9	11.6	10.3	23.3	18.8	13.6	38.3
Rolling after sowing	16.3	14.1	10.1	25.3	18.9	13.2	38.9

Table 6 shows the results obtained in expe ments on less fertile land.

Thus, in seven experiments out of eleven, ro ing made possible a larger grain harvest. Fro these and other data obtained on the Kamenna steppe we conclude that rolling is a valuable a ricultural method in growing spring grain crop

As the experiment shows, compaction is mo effective on loose soils (for example, on a layer perennial grasses), primarily under such cro as spring wheat and, in particular, in the case presowing tillage at greater than seeding depth Data are available for the Kamennaya stepp which show the favorable effect of soil compaction on the harvest of winter crops when the upper layer of fallow soil has dried up before sowin and when sowing takes place on soil which wa not in fallow but was recently plowed.

In our opinion the favorable effect of rollin on the growth and harvest of spring grain crop is explained as follows: Research by D. P. Burnatskiy on soil moisture relations of the Kamennaya steppe showed that drying out of the roo zone or even of the plow layer is fairly rare, bu drying of the upper 5 to 7 cm. layer of the soi to the wilting point and below takes place ever year in spring (at the beginning of May). Consequently, every spring, even when there is goo total moisture storage in the soil, this layer (i which the seeds are deposited, and which thus contains such important organs as the tillering nodes and secondary roots) dries out. Under these conditions the secondary roots grow poorly or are almost not formed at all (11). It is known that when grain plants are poorly supplied by their nodal roots, the crops often do not fully utilize the soil moisture supply, even in the southeastern part of the country (1, 17). A suggestion was made in the literature that in certain years the most important factor in the plant development is the temperature relation, and not the soil moisture.

Thus, on the Kamennaya steppe, rolling assures quicker and more uniform appearance of the shoots (this is also made possible by uniform placement of the seeds) because it increases the moisture content in the upper (seedbed) layer of the soil and raises the temperature, and also

ecause it reinforces the contact between the
eds and the soil particles. Providing more favor-
ble moisture relations in the zone of the tillering
odes strengthens the secondary rooting of the
lants and improves the initial growth of their
egetative parts. Since setting and differentiation
reproductive organs takes place from the be-
nning of vegetation, rolling is favorably mani-
sted on the development of the spike and its
mponents. The conditions brought about by
lling cause a definite spurt in growth and de-
lopment of the plants, stimulating them when
ung, just at the stage when the organism is most
pable of adaptation to change. Plants with
rger bodies, better supplied with nodal roots
d having better developed reproductive organs,
ve larger harvests.

Harvest increase with compaction may not
ke place if the air is too dry in the second half
the growing period. Under these conditions
ere is no advantage of compaction in the growth
d development of plants, since on non-com-
cted soil, plants with smaller bodies expend
eir moisture more economically and form better
ain. Nor does the harvest increase when too fre-
uent rain keeps the moisture in the upper soil
yer at a fairly high level.

Thus, an increase or decrease in the harvest
ving to a change in soil density must, in our
pinion, be explained by a complex of causes. It
the function of agronomy to reveal these causes
that action directed at the plants' external
nvironment may fully satisfy their require-
ents. We noted that Mal'tsev (12), (cited by
nel'nikov to confirm his own views) specifically
nphasizes that "... the nature of the interaction
plants and soil must be discovered: we must
nd out how compacted soil acts on the plant
nd how the plant growing on dense soil acts on
in turn." Profound and detailed research in
is direction is extremely necessary.

Conclusions

Compaction of the soil exerts a substantial in-
uence on the growth and harvest of spring grain
ops. The causes of increases or decreases in the
rvest with changes in soil density have not yet
een established. It is not confirmed under Ka-
ennaya steppe conditions that, as soon as the
il moisture falls below the field capacity, roll-
g will allow conservation of soil moisture and
nsiderably improve moisture relations, not only
in the surface layer, but in the entire root zone. Nevertheless rolling before or after sowing usually increases the harvest of early grains and is a valuable agricultural method. The favorable action of rolling on the growth and harvest of plants is explained by a complex of causes, including more uniform distribution of the seeds in depth, reinforcement of the contact between the seeds and the soil, more favorable hydrothermal soil relations in the zone of sprouting and tillering nodes, better growth of the nodal roots, and so forth.

The study of the requirements of plants for optimal soil density and the development of agricultural methods for satisfying these requirements is extremely necessary.

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HE EFFECT OF ALFALFA AND SAINFOIN ON THE AVAILBILITY OF PHOSPHORUS IN IRRIGATED CHERNOZEM SOILS

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THE TOTAL quantity of phosphorus in chernozem soils is usually sufficient for meeting the lant requirements, but the easily available forms re of decisive importance for crops, and these are ften found to be very inadequate. In irrigated griculture crops must often be grown in salinized ils where, as a rule, an increased osmotic presure of the soil solution is noted: this considerably wers the plant's intake of nutrients, including $_2O_5$, (8). It is necessary to find means of increasg the availability of soil phosphates under irgated conditions.

It is known that different species of plants have fferent capacities for assimilating poorly soluble hosphorus compounds. Such farm crops as lune, buckwheat, mustard, lentils, and perennial guminous plants can not only utilize low solue phosphorus compounds themselves, but can so enrich the soil thereafter with available rms of P_2O_5 (1, 9, 3, 13, 11). This enables us to e those plants whose roots have a solvent acon to enrich the soil with easily available forms phosphorus.

In the literature there are data on the improveent of the phosphate nutrition of plants after e sowing of perennial plants (2 and others). infoin is particularly valuable in this respect).

From 1951 to 1957 inclusive we made a comrative study of alfalfa and sainfoin crops in e chernozem soils of the Kuybyshev region. mong other questions we studied the effect of falfa and sainfoin for enriching the soil with sily available forms of phosphorus. We comred the content of separate groups of phoshates, using Chirikov's method (10), in soil mples from two-year-old unmixed alfalfa and infoin sowings. The total phosphorus content s determined in an extract with aqua regia. cording to Chirikov (10) and Shkonde (12) the soil phosphorus is divided by differential tractions into five groups, differing in their lubility in individual chemical reagents. This lubility determines to a known degree the availility of the phosphorus.

First group—phosphates extractable from the soil with water saturated with CO_2 to 0.05 to 0.06 N (Chirikov) or 0.08 N (Shkonde). This group includes alkali phosphates, acid, neutral, and some basic phosphates of alkaline earths, and labile phosphorus esters. This group of phosphates is easily available to plants in all soil types and is usually fully assimilated.

Second group—acetic-acid-soluble phosphates, extracted from the soil with 0.5 N CH_3COOH. This includes neutral and basic phosphates of alkaline earths, some phosphorite, $AlPO_4$, and also phytates of Ca, Mg, and Al. This group of phosphates is easily available to all plants in acid and weakly acid soils, but is less available in neutral and alkaline soils.

Third group—phosphates soluble in 0.5 N HCl (for carbonate soils) or in 0.5 N H_2SO_4 (for carbonate-free soils). This includes the R_2O_3 phosphates of apatite and phosphorite, titanium phosphates, Fe phytates, and mononucleotides. These phosphates are less available to plants in all varieties of soil.

Fourth group—organic phosphates extracted from the soil with 3.0 N NH_4OH (Chirikov) or 25% superoxal (H_2O_2) (Shkonde). This group includes polynucleotides, phosphoproteins, phosphatides and titanium phosphates, which are practically unavailable to plants. After biochemical or chemical decomposition the organic phosphates supplement the available forms of phosphorus (6).

Fifth group—phosphates not extractable by the previous reagents: titanium phosphates, and those of fluosilicic acid and of unweathered parent materials, and also apatite in feldspar nodules. The phosphates of this group are completely unavailable to plants. They are weathered extremely slowly.

The five groups of phosphates are determined on the basis of the difference between the total phosphorus content and its content in the HCl-extract + organic phosphates (that is, in the third and fourth groups).

For determination of the separate groups of

TABLE 1

Forms of phosphates in soil sown with alfalfa and sainfoin

Plant	Total P_2O_5		Distribution of total phosphorus by groups													
			Soluble groups								Insoluble groups					
	mg./kg.	% soil by wt.	First		Second[a]		Third[a]		Sum of groups I + II + III		Fourth		Sums of groups I + II + III + IV		Fifth	
			mg./kg.	%	mg./kg.	%	mg./kg.	%	mg./gm.	%	mg./kg.	%	mg./kg.	%	mg./kg.	%
Alfalfa	1068	0.107	12	1.07	271	25	123	11	406	38	602	56	1008	94	60	5.6
Sainfoin	1046	0.105	43	4.13	216	21	199	19	458	44	552	53	1010	97	36	3.5

[a] By deduction of phosphorus in the preceding groups.

phosphates, soil samples were obtained at ten points of an experimental plot (3000 sq. m. in size), at a depth of 0 to 30 cm. Soil samples from all points of the plot were combined, reduced to an air-dried condition, pulverized, and sifted through a 1 mm. opening sieve. After this the analysis was made. The results obtained are presented in Table 1.

Table 1 shows that despite the almost equal content of total phosphorus in the soil, its distribution by groups of phosphates was somewhat different in sowings of alfalfa and sainfoin. In sowings of sainfoin, the content of the first group of phosphates (those most accessible to plants) was greater than in alfalfa sowings (44 as against 12 mg./kg. of soil). The sum of the first three groups of phosphates—those most available to plants—was also greater in sainfoin than in alfalfa sowings 458 as compared with 406 mg./kg. of soil (44 as compared with 38% of the total P_2O_5).

Thus, on the basis of experimental findings, we conclude that sainfoin is more capable than alfalfa of converting the poorly available soil phosphates into forms which are readily available to plants. This means that the phosphate nutrition of plants after sainfoin should improve to a considerable extent.

Earlier, we also investigated the superiority of sainfoin over alfalfa with respect to the nitrogen reserve in the soil and the improvement of the soil structure (6, 7). The properties of sainfoin previously mentioned apparently also have a favorable effect on the yield of subsequent crops. Thus, in our experiments on ordinary chernozem under irrigation the yield of table beets after alfalfa was 369.3 centners per hectare; after sainfoin, 428.4; after mixed grasses, alfalfa and brome grass, 392.4; and after sainfoin + brome grass 481.3.

We must conclude that sainfoin, by virtue of its favorable effect on the nutritional regime, including its influence on the content of available forms of phosphorus to plants, and thus in increasing yields of subsequent crops, has a considerable advantage over alfalfa.

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CAUSES OF PLANT COVER PATCHINESS IN EASTERN KAZAKHSTAN

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THE LAND which is suitable for irrigation in Zaisan and Markakol' districts, Eastern Kazakhstan Region, is located on the piedmont plains of the northern slopes of the Saur-Tarbagatay and the southern spurs of the Altay. These plains are steeply falling surfaces with slopes of 7 to 10 in 1000. The soils have a high content of particles larger than 1 mm. in diameter and below the 40 to 80 cm. layer are underlain by alluvial-colluvial angular gravelly-cobbly deposits. The mantle of covering clay loams on the rocky train becomes thinner as the content of particles greater than 1 mm. in diameter increases. In texture the covering soil usually consists of coarse and medium clay loams (Table 1) and is generally a light chestnut soil.

While making a scientific investigation on the virgin areas of these plains we encountered an interesting phenomenon—clearly manifested patchiness of the plant cover. The patches are a combination of white *Artemisia*—feathergrass or feathergrass spots of *Stipa capillata* and *Artemisia incana* with *Salsola brachiata* and *Ceratocarpus turkistanicus*.

By the end of summer the small, mixed, annual plants completely dry up and the steppe takes on an especially pronounced patchiness.

In spite of the most careful observation we determined no visible differences in the morphology of the soil profile under these completely different communities. Descriptions of the two profiles are given for comparison.

Profile 22.

Under small, mixed plants.

A_1 0–10 cm.
Light cinnamon-brown coarse clay loam, dry, slightly penetrated by roots. Transition gradual.

B_1 10–35 cm.
Noticeably darker medium clay loam with isolated inclusions of angular and small gravel. Structure fine-cloddy. Transition to next horizon gradual.

B_2 35–75 cm.
Light cinnamon-brown coarse sandy clay loam, somewhat pale from carbonates, compact, with a large amount of gravel and angular gravel. Below 75 cm. there is a deposit o gravel and angular gravel with sand particle of varying size.

R (underlying rock)
75–150 cm.
Gravel-angular gravel deposits. Effervesce with HCl along the entire profile.

Profile 21.

Under white *Artemisia*-feathergrass vegetation.

A_1 0–14 cm.
Grayish-cinnamon brownish medium clay loam, dry, thickly permeated with roots. Structure loose fine-cloddy. Transition to next horizon gradual.

B_1 14–30 cm.
More compact dry medium clay loam with isolated inclusions of gravel and angular gravel. Structure slightly cloddy or subangular blocky; loose. Penetrated by roots. Transition to next horizon gradual.

B_2 30–35 cm.
Sandy, light cinnamon brown carbonate coarse clay loam with a large number of inclusions of gravel and angular gravel. Transition fairly sharp because of increased amount of gravel and angular gravel.

B 55–90 cm.
Sandy loam with gravel and angular gravel 0.5 to 3.0 cm. in diameter continuously coated with lime; many roots.

90–165 cm.
Gravelly-angular gravelly-cobbly deposit with particles 0.5 to 15.0 cm. in diameter and sand with grains of various diameters. Effervesces with HCl from 2 to 3 cm. down the remainder of the profile.

Regardless of the identical morphology of the soil profile and the similarity in lithology the feathergrass community was located only where the gravelly-angular gravelly deposits were located at a depth of not more than 40 to 60 cm. (see Fig. 1). The upper part of these deposits was usually continuously penetrated by feathergrass roots. When the clay loam soil was very thick (more than 60 cm.) the feathergrass community (the first component) was replaced by small, mixed plants (the second component).

TABLE 1

Texture of angular gravelly-cobbly deposits as percent of oven-dry subsoil

Depth of sample, cm.	Sieve analysis with further particle size analysis									
	100 mm.	100–80	80–40	40–20	20–5	5–3	3–2	2–1.0	1.0–0.25	0.25–0.05
60–70	0.0	1.9	16.5	19.1	24.1	6.5	11.3	9.9	2.8	2.2
85–100	4.0	0.2	20.0	16.0	19.5	6.0	3.6	13.0	10.5	5.2

Depth of sample, cm.	Sieve analysis with further particle size analysis						
	0.05–0.01	0.01–0.005	0.005–0.001	<0.001	Σ of particles <0.01 with correction for processing loss	% loss in processing	Total particles <1.0 mm.
60–70	2.0	0.5	0.6	2.2	3.2	15.6	10.3
85–100	0.8	0.3	0.3	0.9	1.5	5.8	17.5

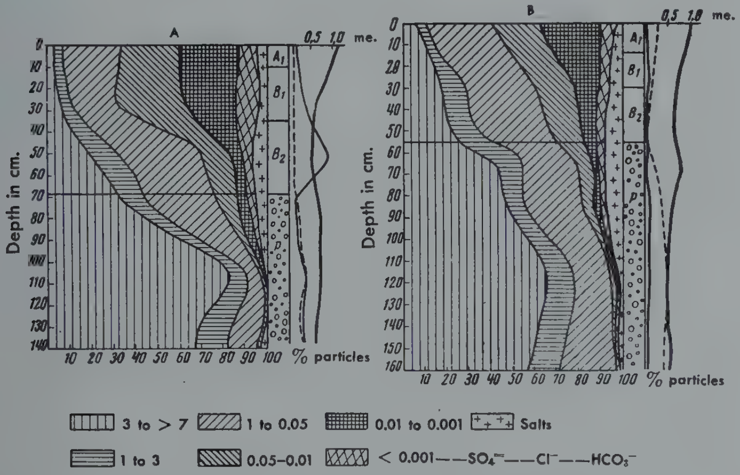

FIG. 1.—Data from analyses of texture and water extracts of soils investigated. A—Light chestnut silt loam on gravelly-angular gravelly deposits. B—Light chestnut silt loam on gravelly-angular gravelly deposits.

Analyses of texture and of water extracts do ot show any great differences (Fig. 1).

The cause of the patchiness must be sought in ydrothermal relations and not in physicochemi-l, morphological, or agronomic properties.

Since there is a moisture deficit during most of he growing season, the feathergrass develops its oot system downward and continuously pene-rates the upper part of the gravelly deposits. he coarse texture of the underlying parent ma-erial makes the small "excess" of moisture ormed under these conditions freely available.

Why is 40 to 60 cm. the optimal depth of the ravelly deposits for the vital functions of feathergrass, and how is "excess" moisture, available to plants, formed here?

Modern, as well as some earlier research (6, 2) shows that the saturation of oven-dry soil to the hygroscopic coefficient occurs at a relative humidity close to 100%. Since, under natural conditions, the absolute soil moisture always exceeds the hygroscopic coefficient, the moisture of the air in the soil obviously must not fall below 100%. This has been fully confirmed by experiments.

In the usual nonsaline or slightly saline soils, even at very low humidity, the total content of bound moisture may be two to four times as great as the hygroscopic coefficient. But the maximum amount of tightly bound (unavailable) water—the maximum adsorptive moisture capacity—is considerably less than the hygroscopic coefficient. Consequently, there is a fairly broad margin between completely unavailable moisture and the maximum content of bound water available to natural vegetation.

The texture of the substratum is of great importance. The coarser the texture, the smaller the hygroscopic coefficient and, consequently, the less absolute soil moisture is required for sorption processes. In coarse-grained material the sorption bonds are characterized by smaller binding forces, therefore loosely bound films are more easily given up. Table 1 shows that the gravelly-angular gravelly-cobbly deposits of the Saur-Tarbagatay have a fairly coarse texture. The value of the hygroscopic coefficient varies from 0.8 to 1.2%, while the natural moisture of these deposits is 2.0 to 3.5%, as determined in 10 kg. samples.

Analysis shows that the depth to which the daily temperature wave penetrates usually does not exceed 80 to 100 cm. At this depth the amplitude of the temperature fluctuation is small, of the order of 0.1°C. or less. The temperature wave drops off sharply with depth. The nature and amplitude of the daily temperature fluctuations in different media are seen in Table 2.

There are great fluctuations in temperature in the coarse soils of mountain and piedmont areas, where there is an abrupt change between hot days and cold nights. Even if the warming and cooling of the soil profile does not affect the moisture in the soil air, it still has an enormous effect on condensation and evaporation, especially on the Saur-Tarbagatay and southern Altay piedmont plains. Warm soil air, saturated with moisture, must condense when it comes in contact with cold surfaces. An increase takes place in th loosely bound film of sorbed soil moisture.

TABLE 2

Diurnal temperature cycle in different media, °C.

Measurement	Granite	Sand	Peat bog	Air
On the surface				
Average daily temperature	23.0	20.8	16.4	16.1
" maximum "	34.8	42.3	27.7	22.7
" minimum "	14.5	7.8	6.3	9.6
" amplitude "	20.3	34.5	21.4	13.1
At a depth of 60 cm.				
Average temperature	20.2	14.1	11.6	—
" amplitude	1.3	0.1	0.1	—

The superficial location of the deposits in a zone where the daily temperature variations have a considerable effect, the coarse texture of the deposits, and the low hygroscopic coefficient at a high relative humidity of the solum air cause a dynamic change in the loosely bound film of soil moisture enabling it to be partially utilized by plants. From the coarse texture of the gravelly-angular gravelly deposits of the Saur-Tarbagatay and the Altay with a natural moisture content o 2.0 to 3.5% (hygroscopic coefficient 0.8 to 1.2%) we can assume that the temperature variations create conditions for the maximum accumulation of bound (sorbed) moisture and also for capillary-condensation moisture (more available).

Why does the second component of the plant cover on gravelly-angular gravelly deposits deeper than 60 to 70 cm. consist to a considerable extent of salt-tolerant species which, under these conditions, grow on non-saline parent material? The constant very low absolute moisture of these clay loams, with no conditions for releasing their large amounts of unavailable water, does not permit the growth of any vegetation except that having high drawing power in the roots (high osmotic pressure in the cell juice of the root hair cells).

If the gravelly-angular gravelly deposits are close to the top of the soil (above the 40 cm. mark) there is quick and considerable warming and even heating through, not only of the surface clay loam but also of these deposits. Therefore evaporation predominates. There are no conditions for condensation. Meanwhile, the soil undergoes a severe moisture deficit (the natural field moisture is much lower than the wilting point). As a result of hydrothermal processes there are not only periodic changes in the film of bound (sorbed) soil moisture but also accumulation of moisture, especially in the coarse-grained media of semideserts and deserts, mountain and piedmont areas and so forth. Original work by Blagoveshchenskiy (1) proved that under conditions of complete isolation the sandy parent material of the Karakumy accumulates considerable supplies of moisture, the first maximum of which lies at a depth of 60 to 80 cm.

Higher plants adapt to utilize moisture given off in the soil and parent material as a result of hydrothermal processes. Grassy plants on sandy and stony areas of arid regions concentrate the naximum number of roots at a depth of 60 to 80 m. Most roots at this depth extend just parallel o the soil surface. There is clear stratification ven in the shrubs and woody types growing along vith these plants. The first layer of roots is at depth of 60 to 100 cm. The ability of feather-rass communities to grow in the Zaysan basin n superficial gravelly-angular gravelly deposits s one of the forms of higher plant adaptation to he surrounding external environment.

Differences in hydrothermal relations caused y fluctuations in the thickness of the mantle of lay loams covering the gravelly-angular gravelly leposits cause the patchiness of the plant cover f eastern Kazakhstan.

Conclusions

1. Temperature fluctuations in coarse-grained oils and parent material permit a definite ac-umulation of moisture in them.

2. The different structure, texture, content of articles larger than 1 mm. in diameter, thick-ess, and two-component composition determine he quantitative aspect of this process, making ossible the formation of areas of differing mois-ure content within the soil.

3. The differing moisture content of the soils nd parent material of individual areas serves as basic cause of the patchiness of the plant cover f eastern Kazakhstan.

4. The patchiness of the plant cover may be aused not only by hydrologic and meteorological factors, salinization processes, and so forth, but also, under certain conditions, by the hydrothermal relations in the soil and parent material.

5. The accumulation of moisture in the soil may take place not only as a result of precipitation, but also by means of condensation from the soil air. In desert areas these processes are so intensive that they are the basic source of water for the wild flora.

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Reviews

A NEW SCIENTIFIC WORK ON THE MOUNTAIN-FOREST SOILS OF BULGARIA[a]

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The Forest Institute, Academy of Sciences, USSR has recently published a brief scientific study on the forest soils of Bulgaria by S. V. Zonn. It is based on field observations made by the author during a short trip to Bulgaria in 1955, on analyses (at the Forest Institute, Academy of Sciences) of soil samples which he brought back, and on data in the literature. On the whole this work is an original scientific investigation, especially valuable because theses soils have been so little studied.

Zonn's book begins with a fairly broad introduction explaining the scientific principles of his biogeocoenotic approach to soils. As he states, the basis of such an approach consists in thinking of the soil as an integral component of biogeocoenoses. A biogeocoenosis means "a definite area characterized by the distinctive development of flora and fauna which exist in an interrelation with the surrounding climatic and soil environment."

It seems to me that no modern genetic soil scientist or geographer will disagree either with Zonn's opinions regarding the interpretation of soils given above or with any of the other theoretical ideas expressed in the book which sum up the essence of the biogeocoenotic approach.

Only one question may arise about such an approach: how does it resemble or differ from the usual scientific principles of modern Dokuchayevian genetic soil science, as enriched by the progressive ideas of V. R. Williams' doctrine of the leading role of the biological factors in soil formation? There is no direct answer to this question in Zonn's book, although the author's devotion to the biogeocoenotic approach should oblige him to explain such a question.

After a brief survey of the literature, Zonn' book characterizes some of the specific soil forming conditions under Bulgarian forests. The author's most successful characterization is o the vegetation of the forest itself, which now occupies more than 30% of the entire area of the country and was even more widespread in the recent past. He notes that the geographical distribution of Bulgarian forests clearly shows vertical zonality, the lower zones being occupied by oak forests, the intermediate ones by beech forests and the upper ones by mixed fir-spruce and by pure spruce and pine forests. The characterizations of other conditions of soil formation, particularly of the climatic and geomorphological conditions of the forest districts of Bulgaria, are regrettably not brief and there are some annoying inaccuracies (for example, the encroachment of warm and dry masses of air from the Atlantic ocean, or the anticyclonal type of climate in the central and eastern parts of Bulgaria, and so forth).

Further, this book gives important factual data on the ash content of organic debris under forests of differing composition. These data show significant differences in the ash element cycle between the soils and the vegetation in forests of varying composition: the existence of such differences is very important for a future survey of the genetic properties of forest soils.

The principal part of the investigation characterizes the soils under the commonest types of Bulgarian forests. In every case descriptions of typical soil profiles and some analytical data are given.

Zonn draws his most definite genetic conclusions from the data on the soils of beech and oak forests. For beech, he establishes the development of fairly typical brown forest soils, both satuated and unsaturated. All three profiles of simi- ar soils given in the book are characterized by a eutral reaction, low exchangeable acidity and a early pronounced biological accumulation of ex- hangeable cations. However, particle size analy- s shows no noticeable signs of clay movement. nder the oak forests of the northern Rhodope ountains, the Stara Planina, the Dobruja and e Black Sea littoral, Zonn describes soils of two enetic types; brown forest and chernozem. He oes not distinguish either gray forest or the nique degraded cinnamon-brown soils which I. . Antipov-Karatayev and I described in Bul- aria in 1948. In my opinion the analytical and rofile data given in the book do not fully con- rm these genetic findings of Zonn's. Thus the oil of profile 16, from an oak forest on the north- n slope of the Stara Planina Mountains, is clas- fied by the author among brown forest soils, though it is very similar to gray forest soils. It ontains a large amount of humus (1.0 to 1.5%) own to a depth of half a meter and shows pro- ounced illuviation of clay particles (27% in the pper profile, 29 to 44% in the lower) which is ot characteristic of brown forest soils (see bove). The soil of profile 19, from an oak forest n the Dobruja plain, is classified by the author mong leached chernozems although it is more eminiscent of a dark-gray soil; it is deeply col- red by humus (1.0 to 1.5% at a depth of 40 to 0 cm.), and has a slightly acid reaction (pH 5.6) n the lower part of the profile and a distinct ovement of clay particles (31 to 33% in the pper part and 40 to 43% in the lower).

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[a] S. V. Zonn. 1957. Lesnye pochvy Bolgarii (The forest soils of Bulgaria). Izdatel'stvo Akad. Nauk. SSSR. Moscow.

Zonn gives very interesting data on the soils nder spruce and fir forests, which occupy large reas of the Pirin, Rila and Rhodope Mountains. e classifies the soils under fir forests as brown rest soils, and makes those under spruce forests special type, distinct from all others. These st soils have an acid reaction (pH 4.2 to 5.5), re very rich in humus (10 to 12% under the lit- r), have a high exchange capacity with much xchangeable hydrogen (up to 50 to 60% of the tal exchangeable cations), and show conspicu- us exchangeable acidity, chiefly because of alu- inum. Further, neither the morphological data or the particle size analysis of these soils show ny characteristics of podzolization. All such roperties actually show that the soils under ruce forests are unique. Zonn emphasizes the considerable distinction between them and the soils of fir forests. He refers to the less acid reaction of the latter (pH 4.7 to 6.0), the lower humus content (7 to 9% under the litter), the lower proportion of hydrogen ions in the exchangeable cations, and so forth. All these are reasons for classifying the soils of spruce forests among the brown forest soils.

However, because of some very interesting data on the composition of the organic matter in the forest soils of Bulgaria, which are given at the end of the book, showing that brown humic acids combined with Al and Fe (less often with Ca) occur in greater abundance than fulvic acids, Zonn is obliged to note that "according to the composition of their humus, the soils under fir forests are transitional between the soils under spruce and the typical brown soils. . . ." Strictly speaking, this general conclusion agrees fully with other characteristics of the soils described.

Zonn's data on the soils of pine forests are of great interest. They show that only in the soils of such forests (primarily those made up of *Pinus peucea*) in the mountain regions of Bulgaria are there clearly expressed characteristics of the development of podzolic phenomena; for this reason the author has designated them brown-podzolic soils. Zonn quite properly emphasizes this occurrence, noting that "one of the most interesting of the specific characteristics of soil formation in this country—the absence of pronounced podzolization—appears to exist regardless of external conditions favoring the development of podzolization." The author uses this conclusion as a basis for expounding his ideas on the unique forms of development of soil processes under the Bulgarian mountain forests at the beginning of the book. Such forms are closely related to the unique climatic conditions of this southern country. "The example of Bulgaria," Zonn writes, "enables us to see that the action of the basic forest-forming types of trees may change abruptly, depending on climatic conditions. It emphasizes once more the thesis developed by L. I. Prasolov, that bioclimatic factors play an important part in soil formation."

One cannot fail to support this general conclusion and thus the extremely favorable contribution which the author has made to the soil science of a brother socialist country.

IS SUCH A BROCHURE NECESSARY?

G. P. Surmach

In 1955 Sel'khozgiz (the agricultural publishing house) published a brochure entitled "Control of Drought and Soil Erosion" by G. A. Cheremisinov, M.S. (Agric.) under the editorial supervision of and with a foreword by Prof. S. S. Sobolev.

On the basis of his own data, and that from experimental stations and leading collective farms of Penza region, the author touches on a wide range of questions. He considers the extent to which soils on slopes have been eroded, their water relations, runoff and erosion dynamics, and different methods of controlling erosion and drought on land having dissected relief. The brochure is written on a theme of current importance and would be significant from the standpoint of scientific agricultural production if the content had been handled at the required scientific level. Unfortunately, there are extremely substantial shortcomings in the brochure which will be taken up in some detail.

It should be noted first that the data given in the brochure deal only with Penza region, while the title indicates a broader significance.

In characterizing the distribution of eroded soils in some of the districts of Penza region the author notes that eroded soils extend over 30% of the arable land; about half of this 30% is moderately eroded and about a quarter of it is severely eroded: that is, moderately and severely eroded soils occupy about 23% of the arable area. According to Cheremisinov, the moderately and severely eroded gray forest soils amount to 55% of the collective farm "Rodina Radishcheva" (Table 2). But if we consider that what the author understands by "moderately eroded soils" is soils which have lost up to 50% of the humus horizon and that he includes the entire humified profile of the soil in this (A + B) (pp. 14–15), it is then obvious that his moderately eroded soil (to say nothing of the severely eroded) falls into categories which, by other classifications of erosion (including S. S. Sobolev's), would be designated as severely and extremely severely eroded. Thus, the author has given unreasonably enlarged figures for eroded soils for Penza region and for the collective farm where the work was directly carried out. According to established data, ev at the most eroded points of the central fore steppe (Orlov region), soil cover erosion is far le than the figure given in the brochure. It appea to me that the author has also inflated the fi ures for the extent of gully formation (for so machine and tractor stations, 10 to 11% of t arable area) by including gentle, sodded gulli with regular gullies.

The field moisture capacity for the differe parts of the slopes is considered in the brochu without reference to the soil texture. This ha led to contradictions in the text: for example th conclusion on p. 19 that "eroded soils are di tinguished by their lower water-holding capa ity," while some of the figures of Table 3 tend t show the opposite. The stability of the soil stru ture to water is also discussed without referenc to soil texture (Tables 6 and 7), and this practic must be recognized as incorrect. The importan question of the conditions for differential ad sorption of snowmelt and runoff currents is als discussed in less than completely correct form The author says the absorption rate of snowmel depends chiefly on the depth to which the soil i frozen, while actually the rate is determined b the extent of moistening of the soil at which freez ing takes place and also by the presence of ab sence of a superficial crust. Frozen soil whose pores are not filled with crystalline ice particles absorb such water well, but when crystalline ice particles fill the entire pore space the permeability to water falls abruptly. It is just for this reason that the runoff index is high in the years when the soil emerges from the winter in a se verely frozen condition or if moistening took place during a winter thaw. The author is evidently not very well acquainted with these ideas a fact which must be reflected in the quality o other sections of the brochure.

In characterizing the runoff of snowmelt in 1951 on collective farms of Kuznets district, the author says it is from 470 to 721 metric tons per hectare without considering the character of the land, the amount of snow and without adequate factual data (p. 33).

The author also gives an incorrect idea of the xtent of the runoff from heavy rains. According Cheremisinov, "the absorption of water from ummer cloudbursts is from 20 to 32%" (p. 48). he remaining 68 to 80% of the water is lost as urface runoff. A severely underestimated perentage of use of water from cloudbursts is also ven in Tables 12 and 13. Such quantities are een only extremely rarely and under special conitions (for example, on severely trampled rotaon pastures). According to accurate data from he Novosil'skaya Experiment Station, the averge runoff from various productive lands of a rge (500 hectare) watershed with steep slopes uring very heavy cloudbursts amounts only to bout 10% for gray forest soils. In our experients with simulated rain, when there were very vere "cloudbursts" the runoff with normal soil oisture did not usually exceed 30%. Similar data e given in papers by Kol' (4), Hebol'sin and adeyev (7), Fedorov (10), Tsykin (11), Shaoshnikov (12), Shchekleyn (13) and other auhors. It is evident that the figures given in the ochure are unfounded. This explains the auhor's contradictory conclusions (pp. 33 and 48) ith respect to the evaluation of the role of sumer rainfall and the absence of any recommendaons whatever about using it efficiently.

Discussing the moisture relations in the soil ong the various parts of slopes, but without ting any data on the occurrence of percolation, e author attempts to explain the difference in oisture by percolation. His quantitative data ntradict it, especially on convex slopes.

In an effort to show the importance of shelterlts for increasing harvests, Cheremisinov illusates the role of forest strips with an unfortunate ample. Many of his own data appear to have en obtained under conditions which make it possible to compare them with others' data. his is easily detected if the text is read carefully. r example, in Table 21 he gives data on the role the direction in which fall plowing is carried t with regard to the retention of snowmelt. ccording to these data the amount of moisture bsorbed was 101.7 mm. greater (1017 m.^{3}) on a 5° slope with contour plowing and 48.5 mm. eater (485 m.^{3}) on a level tract than when owing took place along the slope. The figures r the additional moisture are improbably high. hy? It appears that on the experimental tracts ith contour plowing the snow cover was 17 cm. icker (as seen from Table 33) than on the acts plowed along the slope. Thus, the importance rather of thicker snow cover than of the direction of plowing is revealed. On p. 73 the author cites even more contrasting figures on the effect of the direction of plowing. When plowing along the slope, the amount of water accumulated in the top 1.5 m. from winter precipitation amounted to 168 m.^{3} but with contour plowing it was 1189 m.^{3}. However, the insubstantiality of these figures is seen even from the fact that the accumulation of moisture on the unplowed tract (stubble) proved to be higher than on the tract fall-plowed along the slope. In another case the oats harvest, regardless of an enormous difference in soil moisture with contour plowing and plowing along the slope, remained at the same level (14 and 13.5 centners per hectare). All these things show that the author has not interpreted properly his own data and thus has failed to evaluate correctly the figures obtained. According to more accurate data from runoff areas (Zhigalov, 2; Kuznik, 5; L'vovich, 6; Surmach, 8) contour plowing gives 4 to 6 mm. (40 to 60 m.^{3} per hectare) more moisture than plowing along the slope. Further, incorrect data can lead to the incorrect conclusion that enough contour plowing has been carried out in the eroded areas to end the erosion. Actually, carrying out contour plowing once is not enough to control erosion.

The author's calculations of erosion (Table 21) showed that with plowing across the slope the erosion was one sixth that of plowing along it (21.4 vs. 124.6 metric tons). However, it is wrong to attribute that difference only to the change in direction of plowing, since another circumstance—the thickness of the snowpack—was not considered. On the tract plowed along the slope the intensity of erosion was higher because the snowpack was thinner and the soil was exposed earlier without protection against the action of descending snowmelt.

Generalizing on runoff, the author of the brochure writes: "Our observations in Kuznetsk district of Penza region have established that during a mild spring on the slopes and especially on those which are eroded or have puddled soil, all the snow accumulated during the winter is wasted." In general such an assertion cannot be considered as true, since on chernozems and dark-gray soils the spring runoff usually does not exceed 50 to 60%, varying widely according to the type of land: for example, on fall-plowed soil it is considerably lower.

Having turned his attention to the retention of snowmelt, Cheremisinov has failed to provide a basis for the methods he recommended. Let us turn to his factual data. Tables 23 and 24 show data on snow strips which have been plowed, corrugated and rolled. At first glance it may seem that the results of the experiments give clear evidence of the usefulness of these methods: for the additional water amounts to 255 to 600 m.^{3} per hectare. However, there were no controls, nor even replication. Tracts which he designated as controls could not fulfill this function because they had much less snow than the experimental ones: the snow left the "control" plots 10 to 11 days earlier even than that on the rolled tracts on which the snow was melting most rapidly. Recommending the retention of snow, the author correctly evaluates the role of snow cover as it affects the harvest. It is all the more incomprehensible why he chose tracts with little snow cover as controls for the experiments; this disturbed the basic requirement for setting up agricultural experiments—observing complete equality of conditions except for the factor being studied. Thus, Cheremisinov had no basis for recommending these methods (rolling corrugated strips and so forth). Again on this subject it must be noted that other authors and I have obtained data showing the uselessness of corrugated and rolled strips of snow (at least for chernozems). For this reason it would be premature to recommend these methods without rigorous investigation over a number of years.

Further, the author recommends packing the snow across the slope by using rollers or weighted sledges covered underneath by iron or veneer; he states that this method "decreases by two or three times the surface runoff of snowmelt and increases the store of water in the soil by 350 to 500 metric tons per hectare" and so forth (p. 61). However, it has been accurately established that packed snow melts at the same rate as unpacked. Because it wastes labor this method cannot be advantageous.[1]

It must be noted that snowmelt retention devices which have been proved are the different methods of creating microrelief in fall-plowed land (ditching, "interruption furrows," and so forth).

Among the other devices for retaining snowmelt Cheremisinov recommends mulching the fall-plowed land with straw or manure. Mulchin of course, is useful for accumulating water in th soil, but it is hardly appropriate to recommen it without determining the materials and metho for mulching and, in this connection, its eco nomic efficiency. In particular the use of manur as a mulch may strongly reduce its efficiency a a fertilizer because it dries out (as may be see from Table 35: here the increment in the winte rye crop due to mulching with manure was onl 0.6 centners per hectare greater than with stra on eroded soil).

The author's discussion of crop rotations i eroded districts is, in general, correct, but i many respects it rather resembles the specialize literature on the subject.

The author's data on the "work" of grass buffe strips gives the impression of being an incidenta observation. Thus, he states that on a slope wher there were boundary strips 2 to 4 meters wid between tracts of different labor crews, the runoff on the right field during heavy rains was 30% while without these boundary buffer strips it was 80%. The corresponding erosion was 30 and 134 metric tons per hectare (p. 67). With respect to the runoff from heavy rain, figures of this order are quite improbable, as stated above. They are also very improbable in relation to the stopping of erosion by these boundary strips. The erosion-preventing role of grassed buffer strips in districts with large amounts of runoff from snowmelt has not yet been adequately studied and the author of this brochure has added nothing new to it.

Recommending diking simultaneously with fall plowing, Cheremisinov proposes mounting two enlarged moldboards per plowshare on a single tractor-drawn plow (p. 74), but if plowing is carried out in the right direction only one enlarged moldboard per tractor-drawn plow is necessary.

The author presents many ideas which are correct in principle but strongly altered in form, demonstrating them by widely exaggerated figures. For example, on p. 90 we read: "In spring, in hot windy weather the soil of the fields of the Kuznetsk district (forest-steppe.—G. S.) which has thawed completely and then puddled sometimes proves to have dried out within only a few hours." If this were so, harrowing of the early cover could not prevent the loss of most of the soil moisture and an annual drought would be inevitable.

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[1] Plowing and rolling the snow in strips is known to be useful for retaining the snow during the winter.

Characterizing the effect of various agricul- ral methods of soil tillage, sowing seeds and ther measures for increasing yields, Cheremi- nov shows crop increments of such magnitude at, according to my calculations, they add up 40 to 60 centners per hectare. Such an ap- roach to the evaluation of generally recognized eful methods can hardly be correct. There is no oubt that many of the figures for the increments re exaggerated and others are unconvincing. he author also appears to have oversimplified e effect of fertilizers on the extent of erosion. hus, according to Table 32, application of fer- lizers to winter rye in the fall reduced the spring osion from 115 to 49 metric tons per hectare, at is, by almost two and half times. But he ows no data on the density of the plant cover ft on the soil from the fall period and does not ckon with the possibility of different under- round currents of water from melting snow on e compared tracts. Obviously the author, hav- g concentrated on the figures, has not analyzed e conditions under which erosion took place. or this reason such a concept of the effect of rtilizers on erosion should not be considered as aving a firm basis.

No credence is inspired by the author's data on rosion during heavy rains because, as a rule, he oes not show the complex of conditions affecting e erosion and ignores one of the principal fac- rs in erosion—the extent of runoff.

The list of shortcomings and errors could be nlarged, but these are enough to evaluate the rochure. Aside from certain data from the enza Regional Experiment Station which Che- misov cites, most of the author's own data ave substantial shortcomings. The author has xpressed a number of incorrect judgments and iven some unfounded or untrue recommenda- ons to those concerned with production.

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Chronicle

INSTITUTIONS FOR SCIENTIFIC SOIL RESEARCH, FEDERAL REPUBLIC OF GERMANY (Jan. 23–Feb. 10)

M. M. Kononova and I. N. Antipov-Karatayev

Our visit to the Federal Republic of Germany was at the invitation of the Federal Organization for Scientific Research in Agriculture (Forschungsanstalt für Landwirtschaft, abbreviated F.A.L.) in Braunschweig-Völkenrode.

Prof. W. Flaig, director of the Institute of Soil Biochemistry of the F.A.L. issued the invitation. The object of the trip was a joint discussion of soil humus: the origin, nature and properties of humic substances; and the function of humic substances in structure formation and nutrition of plants; the nature of the interaction between organic matter and the mineral components of the soil.

Our program also included visits to a number of scientific soil research organizations in various German cities (Göttingen, Hann.-Münden, Bonn, Munich and Hamburg).

We began by becoming acquainted with the F.A.L. Institutes. The F.A.L. was organized after the second world war. Even in 1947 this center was represented by only one institute, but it now comprises 13 institutes in the following groups: 1) soil fertility, 2) plants and animals, 3) mechanization of agriculture, 4) agricultural economics.

We became most familiar with the Institute of Soil Biochemistry (Director, Prof. W. Flaig). The work being done here was directly related to the object of our trip. In connection with our arrival, a two-day colloquium was held with reports by leading scientists (Flaig, Saalfeld, Breyan, Kutzner, Küster, Beutel-Spacher, Sechting, Saalbach, and Schmidt). Work is being done on a number of theoretical subjects in the Institute (the chemistry of humic substances; the biochemistry of their formation; bonding of humic substances with the mineral part of the soil). These complicated questions are being studie by chromatography, infrared spectrography, electron microscopy, x-ray and thermal analysis, ultracentrifugation, osmometry and other methods. In their work wide use is made of micromethods (producing humic substances by chemical and biological synthesis in cultures of molds and streptomycetes).

In the work of the Institute the following subjects are of practical importance: 1) testing artificial structure formers of the Krilium type and 2) use of humic substances as stimulants for plant growth.

While repeatedly coming back to the work of the Institute of Biochemistry and its technical equipment, we also became acquainted with the following other institutes of the F.A.L.:

The Institute for Utilization of Humic Substances in Agriculture (Humuswirtschaft; Director, Professor W. Sauerland). The basic work of the Institute is the development of methods for the most efficient use of organic and green fertilizers. These studies are being performed by permanent field experiments and are associated with chemical analyses and observations on the fauna and microflora of the soils.

The Institute is developing methods of transforming straw and city garbage into fertilizers; for this purpose, in particular, sewage sludge is being composted with vegetable resides (tree leaves). A special part of the work is devoted to to the use of cattle litter for simultaneously producing biogas and high quality organic fertilizer. Biogas is used for domestic use and in agriculture as fuel for tractors and cars.

Use is also made of the slime precipitating in storage ponds for producing gas. The institute s various installations for the compound uti- zation of organic substances to produce gas and rtilizers.

The Institute for Soils Tillage (Director, Pro- ssor H. Frese). Its work deals with the develop- ent of a rational system for the tillage of both ne and coarse textured soils in connection with he use of animal and green manures in crop rota- on. To control and evaluate the methods of llage such procedures are used as cinerecording, alysis of thin sections, determination of the bsorption capacity of the soil (pF), composition its aggregates, permeability to water, and so rth.

The Institute for Cultivation of Meadows (Di- ctor, Prof. A. Könekamp) is studying the prob- ms of meadow cultivation and of fodder storage n particular its ensilage). There are interesting udies on raising about 40 new corn varieties r ensilage; at the present time, this crop has en widely adopted and is quickly spreading roughout the country. Studies of meadow cul- vation are accompanied by economic calcula- ons (productivity, amount of milk per hectare d head of cattle, equivalence in terms of grain op, and so forth). The Institute is studying e use (especially by surface application) of or- nic and mineral fertilizers on meadow lands for reserving stands of grasses of favorable com- osition over long periods. A survey of all mead- ws and pasture lands has been made.

The Institute for Plant Culture and the Pres- vation of Seed Material (Director, Prof. O. ischnich). The basic work is on the development methods for storing potatoes and sugar beets. here are large air-conditioned warehouses to udy the respiration, loss in weight and subse- uent sprouting of potato tubers. A study is also eing made of the effect of various chemical sub- ances and radiation on the germination of seed aterial (potatoes, beets and other crops) and a articularly wide study is being made on the effect gamma radiation on seeds by the use of radio- ctive cobalt.

The Institute for Mechanization (Director, rof. W. Kloth) consists of the following de- artments: physics, soil mechanics, implements, achines and materials.

In this Institute studies are being made of otary tillers and low-power machines (tractors nd so forth). Of interest are various methods of hecking the effect of soil-cultivating implements and machines on the structure of soil (applications of gypsum layers, oscillography, and so forth). The institute coordinates by organizing annual conferences for discussion of basic problems of agricultural mechanization.

The Central Analytical Laboratory serves all F.A.L. Institutes requiring large-scale analyses (the Institutes for Cultivation of Meadows, for Plant Raising, for Soil Biochemistry, for Feeding Animals and others). The F.A.L. has its own experimental plots, greenhouses, special climatic installations and shops (common to the F.A.L. and some also for individual institutes). The staff of the 13 institutes consists of about 550 persons, one fourth of whom have science degrees; the remainder are subordinates and service personnel (laboratory workers, technicians, mechanics and laborers).

As stated, our program included visits to scientific soil research organizations in other German cities during a special trip around the country.

The Institute for Agricultural Chemistry and Soil Science of the University of Göttingen (Director, Prof. F. Scheffer), Göttingen. In this Institute we became acquainted with research on the nature of humus where various new methods are being applied (electrophoresis, chromatography of all kinds, ultracentrifugation, spectrophotometry, phase-contrast microscopy and others). Research has been started in the use of isotopes (Sr^{90} and P^{32}). There are many young students in the Institute working for their doctorates.

In Göttingen we also visited *The Institute for Sedimentary Mineralogy* (Director, Prof. C. Correns). There we became acquainted with composite methods of research on sedimentary rocks; in particular the method of separating them into fractions by supercentrifugation; with the production of specially oriented preparations for x-ray structural analysis of the five fractions of clay; with apparatus for the rapid method of x-raying samples of clay fractions without the use of a camera, and also with cameras in a vacuum or using helium.

Not far from Göttingen, in Hann.-Münden, is *The Institute for Forest Soil Science,* which is associated organizationally with The Department of Forestry, University of Göttingen (Director, Prof. W. Wittich). Its basic work is the evaluation of forests and the problems of fertilizing forest soils (using mineral fertilizers and sowing lupine on forest plantings). In addition, studies are being made of the decomposition of forest litter and the nature of forest soil humus.

In Bonn we were introduced to the work of *The Institute for Soil Science, University of Bonn* (Director, Prof. E. Mückenhausen). This Institute is the center of scientific and methodological work on mapping the soils of all the Federal Republic of Germany at scales of 1:300,000, 1:100,000 and 1:5,000. They are developing principles for estimating site quality of soils for agricultural planning, and for determining the assessed valuation of farms. They are also at work on methods of mapping forest soils. The actual mapping is concentrated in the Soil Departments of the Geological Administrations of every district of the Federal Republic (in Bavaria, Württemberg-Baden, Westphalia, Hesse and others). Organization had begun of a central soil science service for the entire Federal Republic of Germany.

From Bonn we proceeded to Munich, to *The Institute for Soil Science and Ecology of the Forest Center of Bavaria* (Director, Prof W. Laatsch). One of the basic programs of the Institute is studying the cycle of matter in the soil-forest system and the ensuing prolems of providing the woody vegetation with the necessary nutrients (by applying fertilizers). This problem is being solved by the joint analysis of plant and soil, studies of the process of mobilizing the nitrogen of the litter and also by investigating the microbiological nitrogen-fixing process in forest soils. The latter is being studied in experiments using the heavy isotope of nitrogen, N^{15}, for which a special installation is being constructed at the Institute. The Institute experiments on the decomposition of forest litter at permanent stations in Tirol at altitudes of 600, 1,200 and 1,500 m. above sea level.

In Munich we also visited *The Institute for Plant Culture and Protection,* Bavarian Ministry of Agriculture. There we became acquainted with the Department of Soil Chemistry headed by Prof. U. Springer. Its basic work is devoted to two problems: 1) the importance of the prolonged use of manure to accumulate organic matter in the soil and 2) the utilization of municipal garbage for fertilizer. Professor Springer introduced us to his methods of studying the degree of humification of organic fertilizers applied to the soil. The Institute has two experimental stations in the Munich area to carry out expe ments within its program.

Our last visit was to Hamburg-Reinbek, t location of *The Soil Division, Federal Experime tal Center for Forest Culture and Wood.* It headed by Prof. W. Kubiena. The basic progran of the Division are: 1) investigation of the so of tropical countries; 2) biological and chemic processes in the formation of humus in the fore soils of Germany; and 3) the structure of fore soils. We went through the huge museum for so profiles collected by Prof. Kubiena during h investigations of soil cover in many countries the world. We were given the opportunity to ol serve the technique of preparation and examina tion of soil profiles (composition, constitutio and action of biological agents on soil compo nents).

The visit to Professor Kubiena completed ou trip, and we returned to Braunschweig-Völker rode.

During the final days of our stay at the F.A.L we reported on our own work at a special meetin of the Scientific Council.

The subjects of our reports were as follows:

M. M. Kononova: "Humus in the USSR, it nature and function in soil processes," and I. N Antipov-Karatayev: "Soil aggregates and colloid chemical methods of analyzing them."

At the discussions which arose repeatedly during our trip we touched on some very complex and obscure problems of humus such as: the concept of "organic matter" and "humic substances" of the soil; the principles of the structure of humic and fulvic acids; the methods of studying the nature of humic substances (in particular, the possibility of using infrared spectrography); the variety of biochemical pathways in the formation of humic substances; the function of microorganisms in the synthesis of humic substances. Another subject of discussion was the physiological influence of humic substances on plants and the theory of organo-mineral nutrition of plants. Frequent subjects of enthusiastic discussion were efficient methods for isolating organo-mineral compounds from the soil; forms of linkage between the organic compounds and the mineral parts of the soil; the importance of spherical and linear organic colloids in the formation of the soil structure and so forth.

The views of the German scientists on these questions will be presented in subsequent publications by the authors of the present report.

uring our journey we encountered an unfail- gly friendly attitude on the part of F.A.L. offi- als (Professors Plate, Richter, Haumann and eyer) as well as of the scientists of the research stitutions we visited. Wishes were expressed at a more active exchange of literature and utual visits should take place, and that young ecialists be exchanged between the USSR and e Federal Republic of Germany for prolonged udies in their specialties.

We acknowledge with pleasure the attention given to us by the director of the Institute for Soil Biochemistry, Prof W. Flaig and by Dr. G. Beutel-Spacher, both of whom contributed a great deal to the success of our trip.

We hope that the exchange of views on scientific and organizational subjects will be of mutual benefit in the development of scientific relations between our countries.

THE BAKU CONFERENCE ON SOIL EROSION AND ITS CONTROL

K. A. Alekperov

The conference on soil erosion and its control took place in Baku from Sept. 24, 1957, to Oct. 2, 1957. It was called by the Academy of Sciences, Azerbaydzhan SSR at the suggestion of the Soil Erosion Station.

The basic task of the conference was to summarize the results of studies on soil erosion in the mountain and foothill areas of the USSR where water and wind erosion are most common; to lay out soil erosion districts and to establish types of erosion to work out control methods; to introduce such methods into large-scale use; and to increase the fertility of eroded soils.

Among those taking part in the conference were representatives of scientific institutions in Moscow and of the 12 union and autonomous republics, and the representative of the Bulgarian People's Republic, Professor A. B. Biolchev, who was visiting the USSR.

Twenty-nine reports of workers from scientific and production organizations from Gruziya, Armenia, Moldavia, Kazakhstan, Uzbekistan, Tadzhikistan, Kirgizia, the Ukraine, Azerbaydzhan, Dagestan and others were heard and discussed. Thirty-nine participants of the conference took part in the discussions on the reports and in the resolution project.

In his opening talk the president of the Academy of Sciences, Azerbaydzhan SSR, M. Aliyev, emphasized the particular significa of this broad conference devoted to the probl of erosion and its control because of the urge and vital importance of these questions to t Republic.

The reports produced factual data on t causes of erosion and floods, their extent a frequency in each republic and the damage do by them to the national economy. All those w presented reports emphasized that the process of erosion were the results of improper farmi in areas of pasture, forest and agriculture.

Most of the reports at the conference we devoted to agricultural engineering and alpi soil-improvement measures for controlling wate and wind erosion and floods, and to methods soil-improvement, the mechanization of heav work in mountainous terrain and the introductio of scientific achievements into large-scale use.

It was noted that all questions reviewed at th conference should be the subject of the closes attention by workers in agriculture and othe branches of national economy. There must b assurance of the introduction into large-scale us of all scientific achievements directed at con trolling soil erosion and increasing the produc tivity of crops on eroded soils.

HE KRASNOYARSK SECTION OF THE ALL-UNION OCIETY OF SOIL SCIENTISTS

M. Mayboroda

THE Krasnoyarsk Section of All-Union Society of Soil Scientists numbers 17 members. unites soil scientists, agricultural chemists and ronomists of the Agricultural Teachers College, the institutes for technical forestry, the hakass Experimental Station for Irrigated rming, and the Soil Detachment of the Regional Agricultural Administration.

At the first meeting of the Section there was a scussion of the report by N. Kazantsev, head the Soil Detachment of the Regional Agricultural Administration, on the results and prospects of soil studies in Krasnoyarsk region.

It was recognized that members of the section ust participate in the dissemination of information and the soil study of the region; in the organization of a soil and agricultural-chemical boratory to carry out large-scale analyses of ils; in helping the agricultural chemical laboratories of the Machine and Tractor Stations; in llecting materials to organize a soil and agricultural chemical museum; and in fostering furer soil studies of Krasnoyarsk region.

At the second meeting of the section we heard and discussed the report of M. V. Kirillov, instructor at the Krasnoyarsk Teachers' Institute, who spoke on "the characteristics of soils in flood areas."

At present, the members of the Section are actively participating in studying the economically valuable features of continuously cultivated and virgin soils (P. Bugakov and N. Kazantsev); the soil geography (M. Kirillov); the change in soil fertility under the influence of tillage (N. Sklyad'nev); the use of fertilizers (N. Mayboroda); and irrigation (M. Tanzybayev).

A soil and agricultural chemical laboratory has been set up at the Department of Soil Science and Agricultural Chemistry, Krasnoyarsk Agricultural Institute; there analyses are being made of continuously cultivated, virgin and idle lands.

In 1958, the Section is planning discussions of some results of soil studies and of the effectiveness of using T. S. Mal'tsev's method of tillage. Plans have been made to provide much more help to agricultural production.

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